The Hood Canal Coordinating Council GIS

geospatial tools for salmon recovery and environmental assessment

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June 2009 Report
In support of salmon recovery planning

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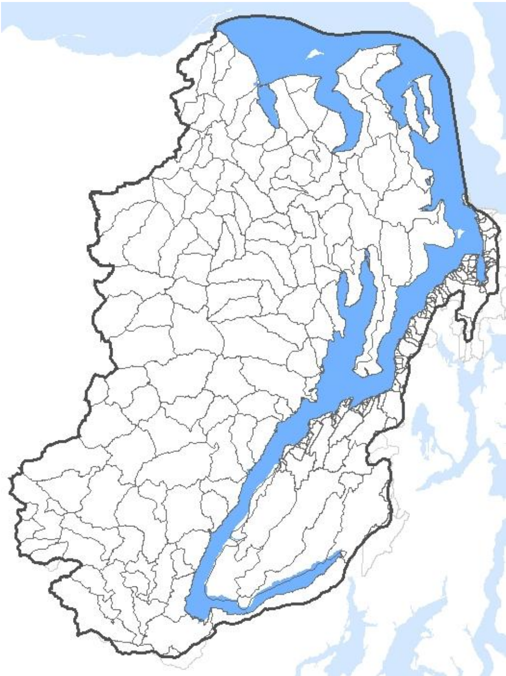
Contents

Analysis Units

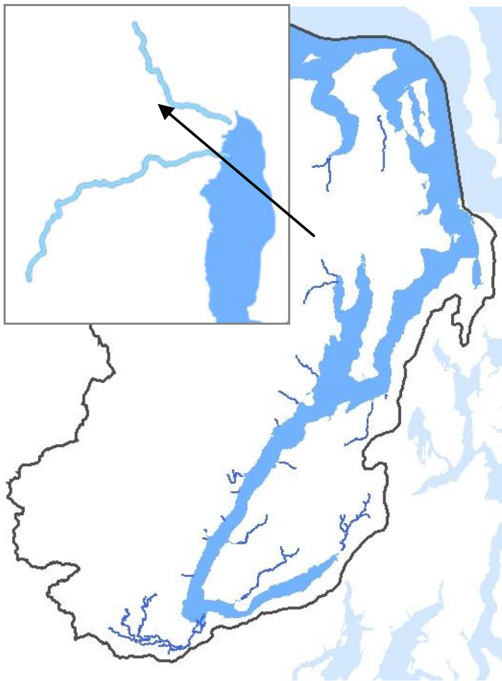
Some of the Hood Canal Coordinating Council's spatial analyses were conducted at a large scale (i.e., the scale of parcels and individual forest harvests). When needed, the data were grouped into analysis units in order to more easily compare them across the whole spatial area. To that end, several analysis unit types were created to facilitate comparison in basins, riparian corridors, conservation units, estuaries, and nearshore zones.

Basins

The summer chum environmentally significant unit (ESU), outlined in bold black to the right, was split into much smaller basin-sized polygons so that information could be grouped into hydrographically relevant zones that can then be compared to one another. The basins can also be consolidated into higher levels (see *Conservation Units*) when needed.

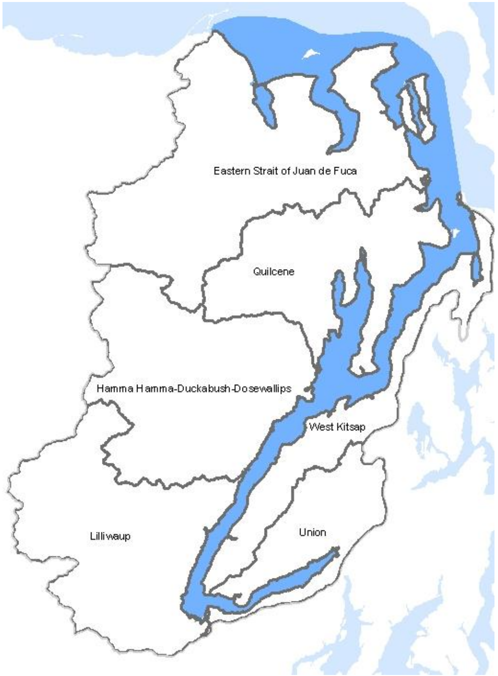


Summer Chum Riparian Corridors



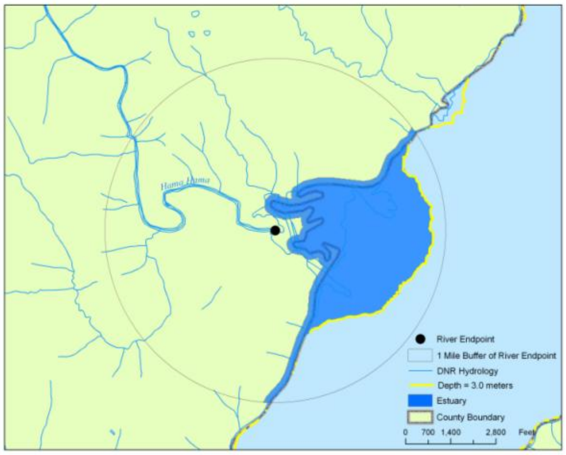
Riparian corridors were delineated along the streams of the extant and extinct populations of summer chum. They are polygons representing 200 foot buffers of the stream lines from the mouths to the upper extent of distribution as determined by the Washington Department of Fish and Wildlife.

Conservation Units

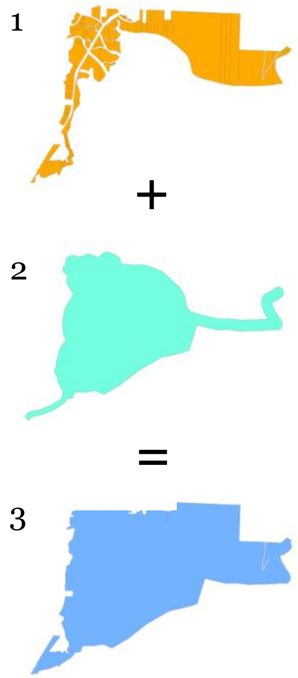


The conservation units represent six mid-sized watersheds within the summer chum ESU that can be used as organizing units for conservation purposes.

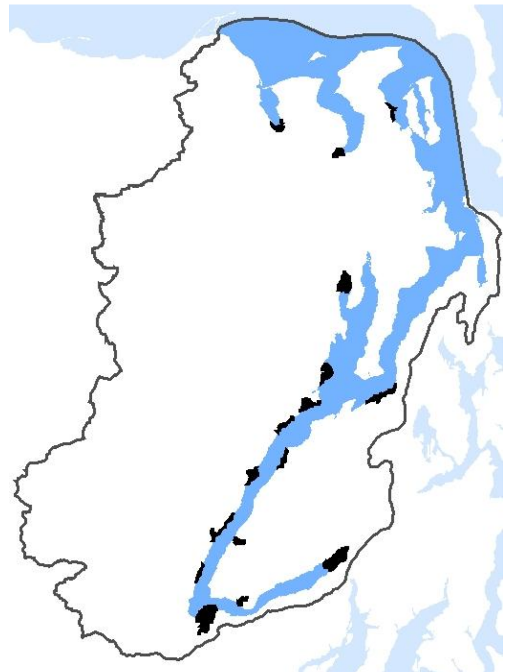
Estuaries



Estuaries around the mouths of the summer chum streams were also delineated. The estuary polygons were created by drawing a one mile circular buffer around the end point of each major summer chum stream (see right). This determined the linear extent up the shoreline that the estuary polygon would encompass. The one exception is the Quilcene estuary which is a combination of the Little Quilcene and the Big Quilcene linear extents. Next, a 200 foot inland buffer of those extents was created and merged with the circular buffers in order to capture the land immediately surrounding the estuary. The county boundary shoreline was used when it matched with orthophotos and the inside Department of Natural Resources (DNR) shoreline was used when it was a better match with the orthophotos. The DNR shoreline represents ordinary high water. The outer extents of the estuaries were determined using a -3.0 meter contour line from the Puget Sound Digital Elevation Model (Finlayson, 2000). The contour line is relative to the mean sea level datum. Finally, the estuary polygons were merged with the parcel geometry, so that the outer extent of those parcels that touched the estuary boundary formed the inland extent of the estuaries (see procedure example and final estuary map, next page).



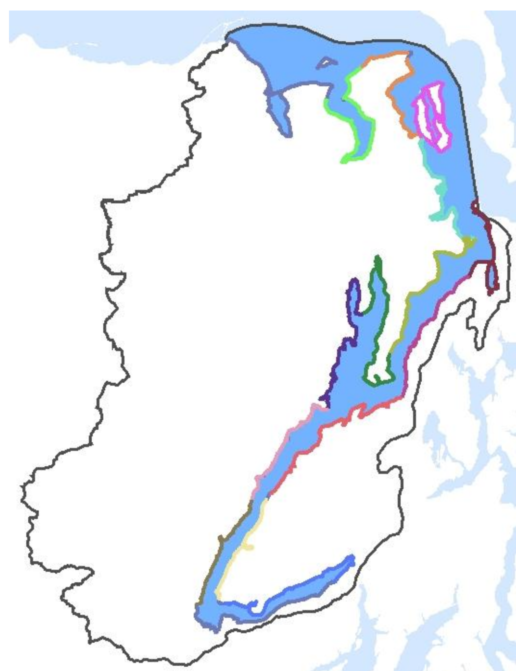
Estuary delineation procedure



Map of estuaries

Nearshore

The nearshore polygons consist of buffers of the shoreline – as defined by the parcel data – buffered inland to 300 feet. The buffers were then split at intervals corresponding to the nearest driftcell locations. They are shown with variously colored lines, right. (In this map, they were artificially widened to be visible at this scale.)



Hood Canal Forest Harvests

Where have forest harvests occurred within the last ten years in the summer chum ESU? This question, to the best of our knowledge, had not yet been investigated even though data existed that could answer the question. Our understanding of the human impacts to the summer chum ESU could be greatly enhanced with this knowledge. To see these data on a basin scale in order to compare cumulative impacts relative to the other stream systems could give us a good start toward understanding whether or not forest harvest has been a significant contributing factor to salmon habitat decline in the *recent* past. Knowing where the forest harvest activity has occurred can also help us gain a more comprehensive view of what is going on at a parcel-scale when combined with buildout analyses, building permits, protected areas, and impervious surfaces.

DATA INPUTS

Two datasets relevant to Hood Canal Forest harvesting were identified:

> **Forest Practices Applications:** The Washington State Department of Natural Resources Forest Practice Application Permit Database was downloaded in May 2006 from the Department website. These data included all permit types including type IV for the years 1995 through 2005. They consisted of polygons representing approved harvest permit areas along with data to go with each permit. Note that a permit does not guarantee that a harvest was actually conducted.
>
> **Olympic National Forest Harvest Database:** The Olympic National Forest, covering much of the summer chum ESU, tracks harvests within its boundaries in this dataset. These data, representing harvest activities such as commercial thinning and

clearcutting, date back to 1910 but only data from 1995 through 2005 were used in order to remain consistent with the forest practices applications data time period. These data were obtained from the U.S. Forest Service in July 2006.

METHODS

According to the data, very few harvests occurred in the Olympic National Forest between 1995 and 2005. Those that did exist were represented in the data well enough for this study and no additional processing on them was necessary.

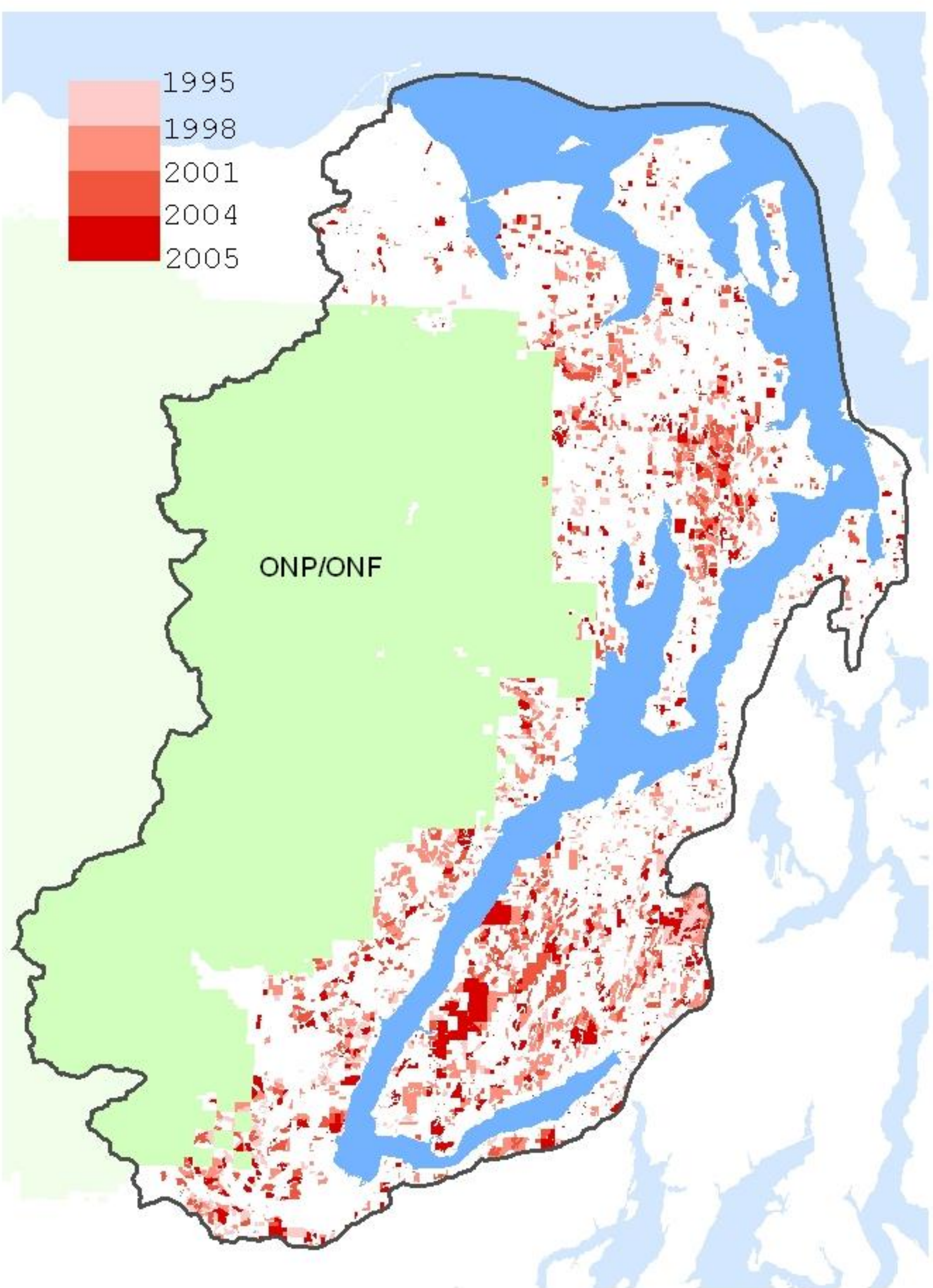
The forest practices applications data from the Department of Natural Resources contained overlapping polygons that represented areas that had been re-permitted over time. This situation would make summing forest harvest within basins and other analysis units impossible. Therefore, these overlaps were dissolved so that only one polygon for each potential forest harvest remained in the database. The date of the most recent permit was retained. This process was conducted via a custom program written in ArcObjects by PetersonGIS.

About the Program: The processing program first cycled through the original database and removed any permits flagged as non-harvest (thus only the harvests remained). Then, the program identified overlapping polygons and worked through the geometry as follows: if two or more polygons overlapped exactly then the one with the earlier date was discarded; if two or more polygons only overlapped somewhat but not exactly, the program kept the overlapping portion with the most current date and separated the non-overlapping portions. The most current permits were always kept as it is most likely that no harvest occurred at the earlier date if a permit was reissued for the same area after only a few years.

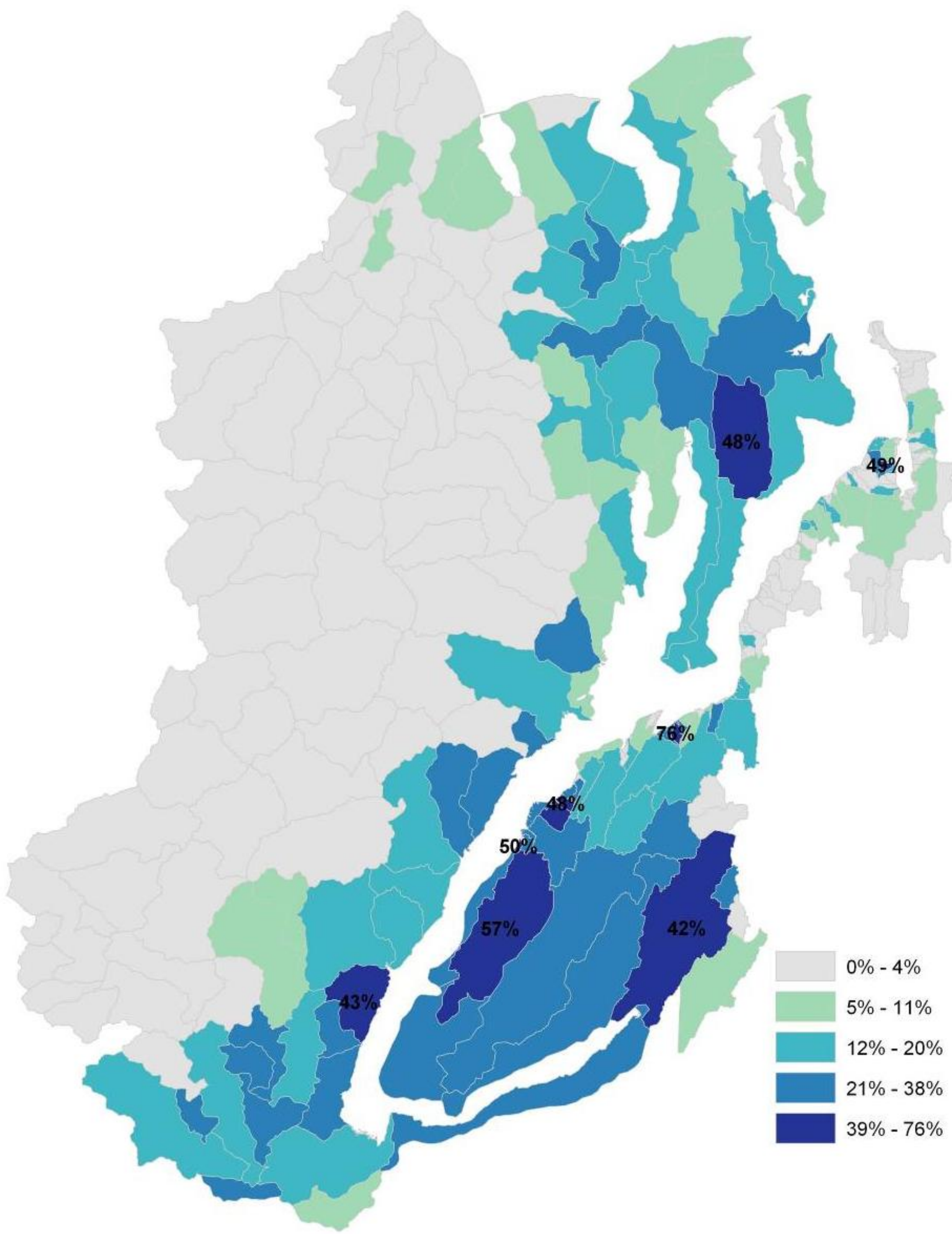
After the data were run through the program, a topologically correct dataset (i.e., no overlaps) was output containing the most recent year of permit for any given area. The year was based on the effective date or renewal date, whichever was later. Only applications flagged in the database as “cutting” or “renewing” timber were output.

OUTPUTS

The output data can be viewed in several different ways. Since the polygons represent the actual permitted area (not the parcel boundary), they can give an indication of where and when a harvest could have occurred. Viewing the data over the entire ESU reveals that much of the area outside of the Olympic National Forest boundary was permitted for harvest at some point during this study’s time period. Total permitted harvest (for all harvest types) for the years 1995 through 2005 accounted for 21% of the summer chum watershed. The maps on the next several pages present the results.



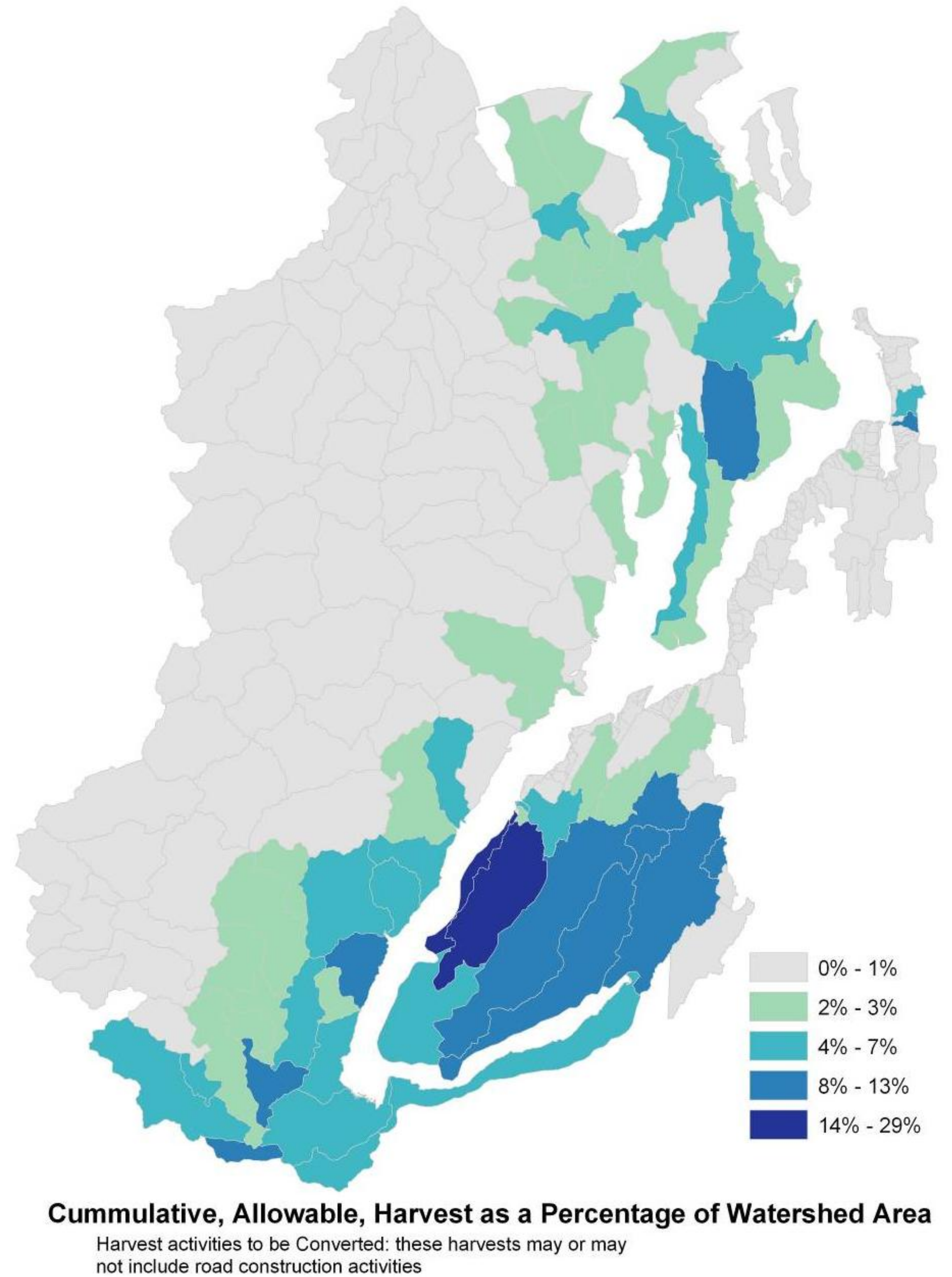
This map shows the locations of forest permit applications, shaded by year of permit.



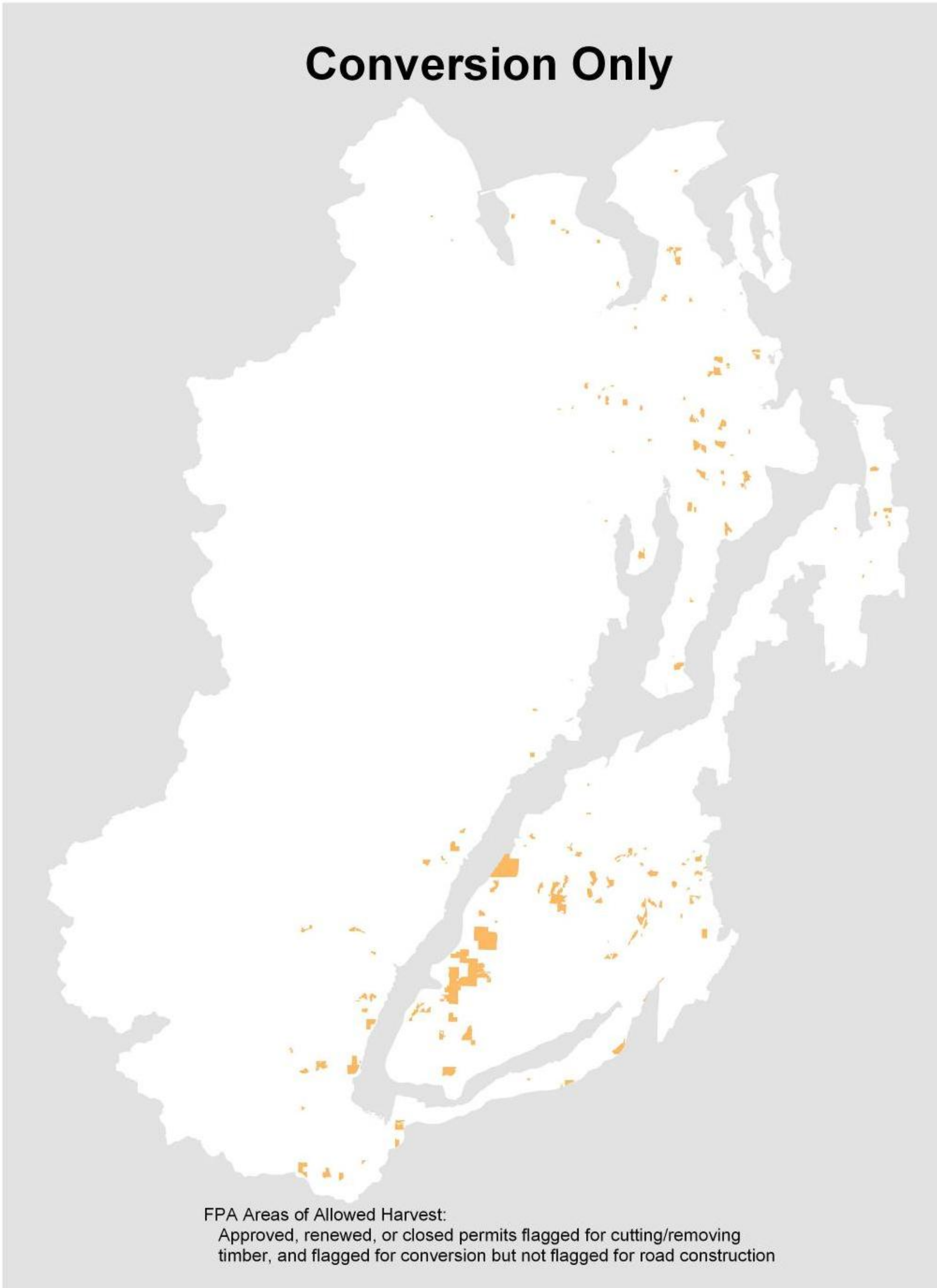
Cummulative, Allowable, Harvest as a Percentage of Watershed Area

All harvest activities: includes harvests with and without road construction and/or road work

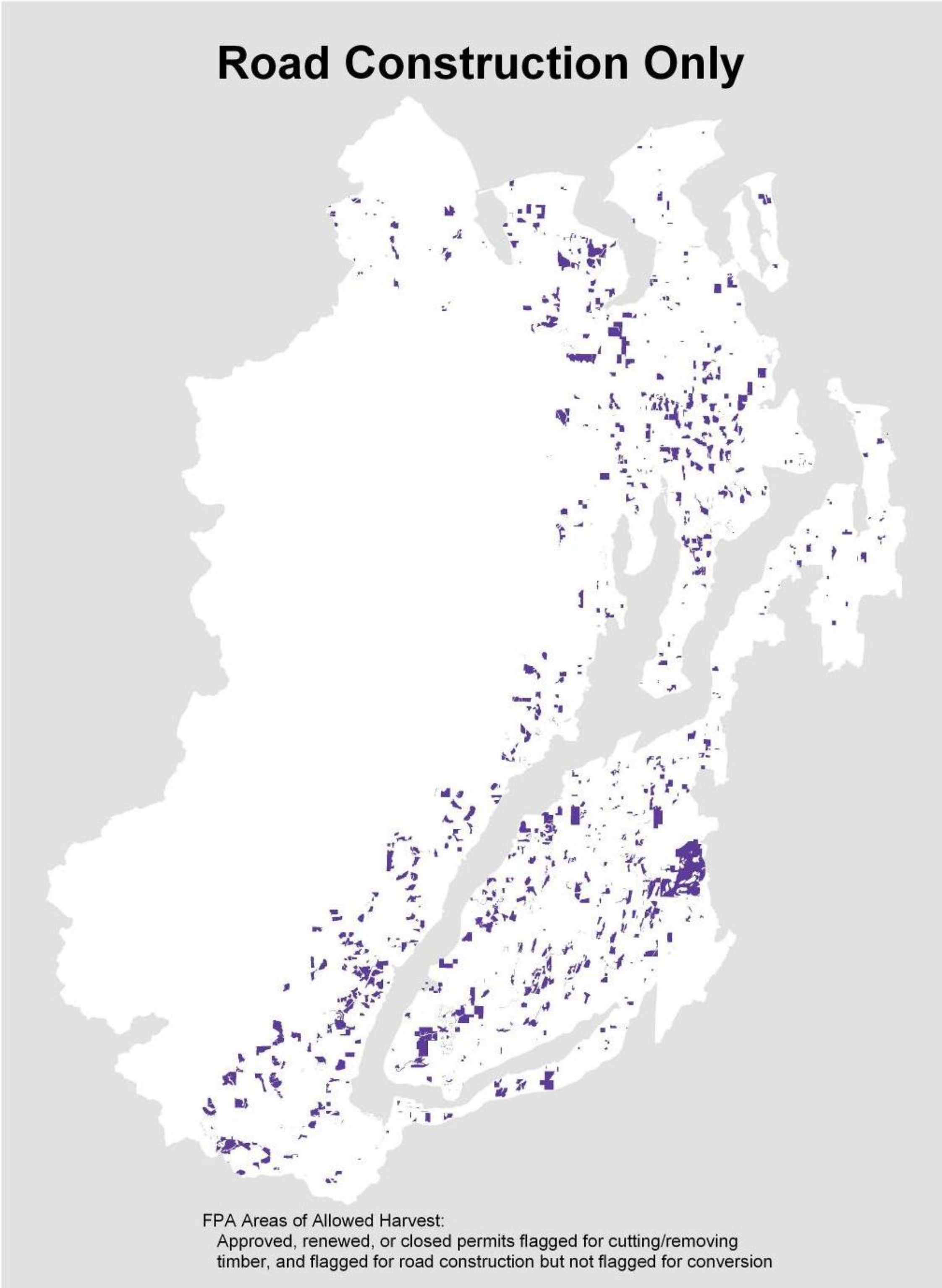
This map shows the forest harvest applications as a percentage of total basin area so that basins can be compared with one another. Some of the basins contained up to 30% harvest (of any type) in single years. In particular, the Dewatto basin showed the largest harvest over time both at the basin and riparian corridor scales.



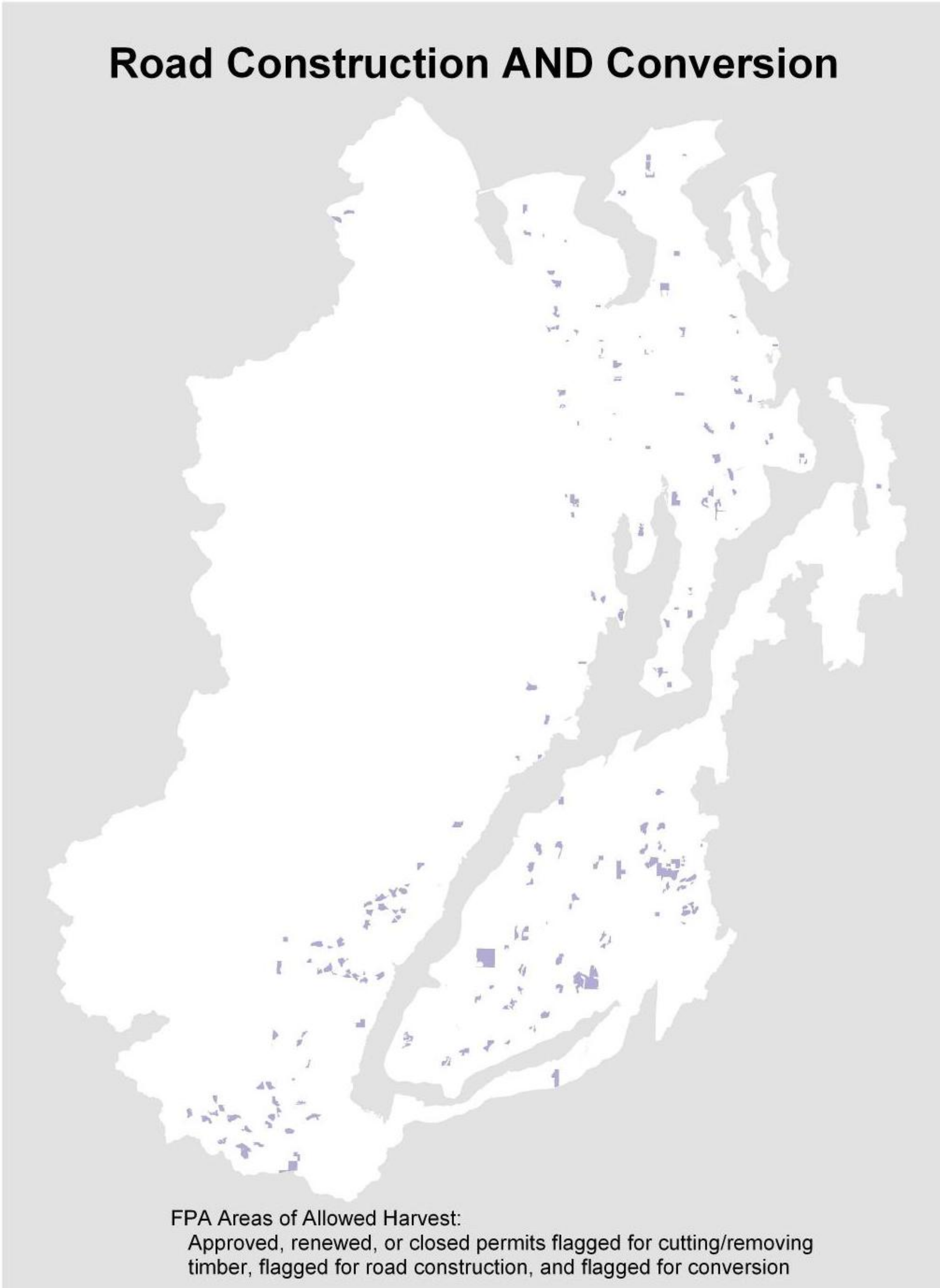
This map also shows the forest harvest applications as a percentage of total watershed area but only the forest harvest applications flagged in the database as conversions (i.e., the forest will be converted to a non-forest use such as residential development) are included.



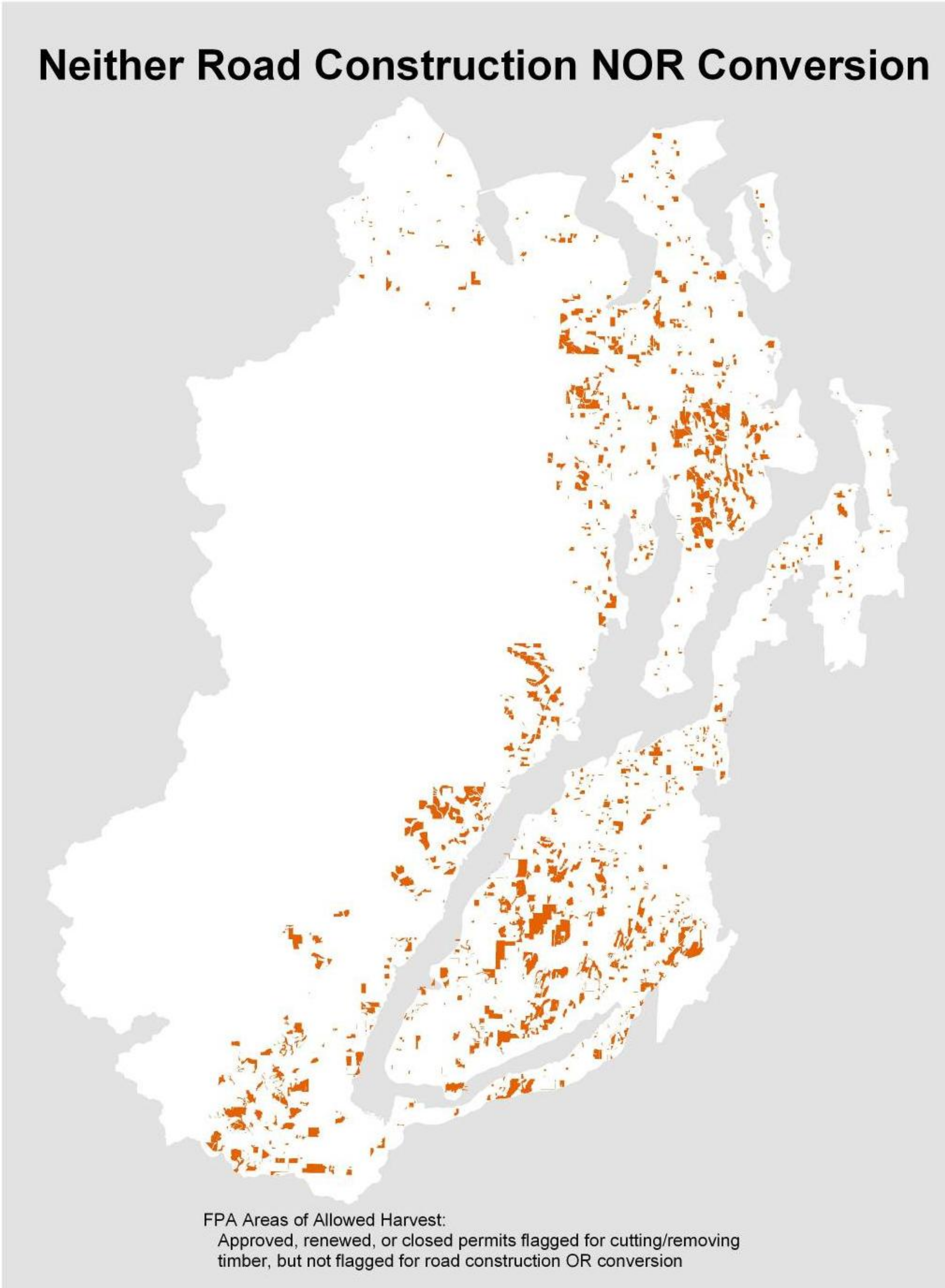
Here, the forest harvest permit applications flagged as conversions are shown.



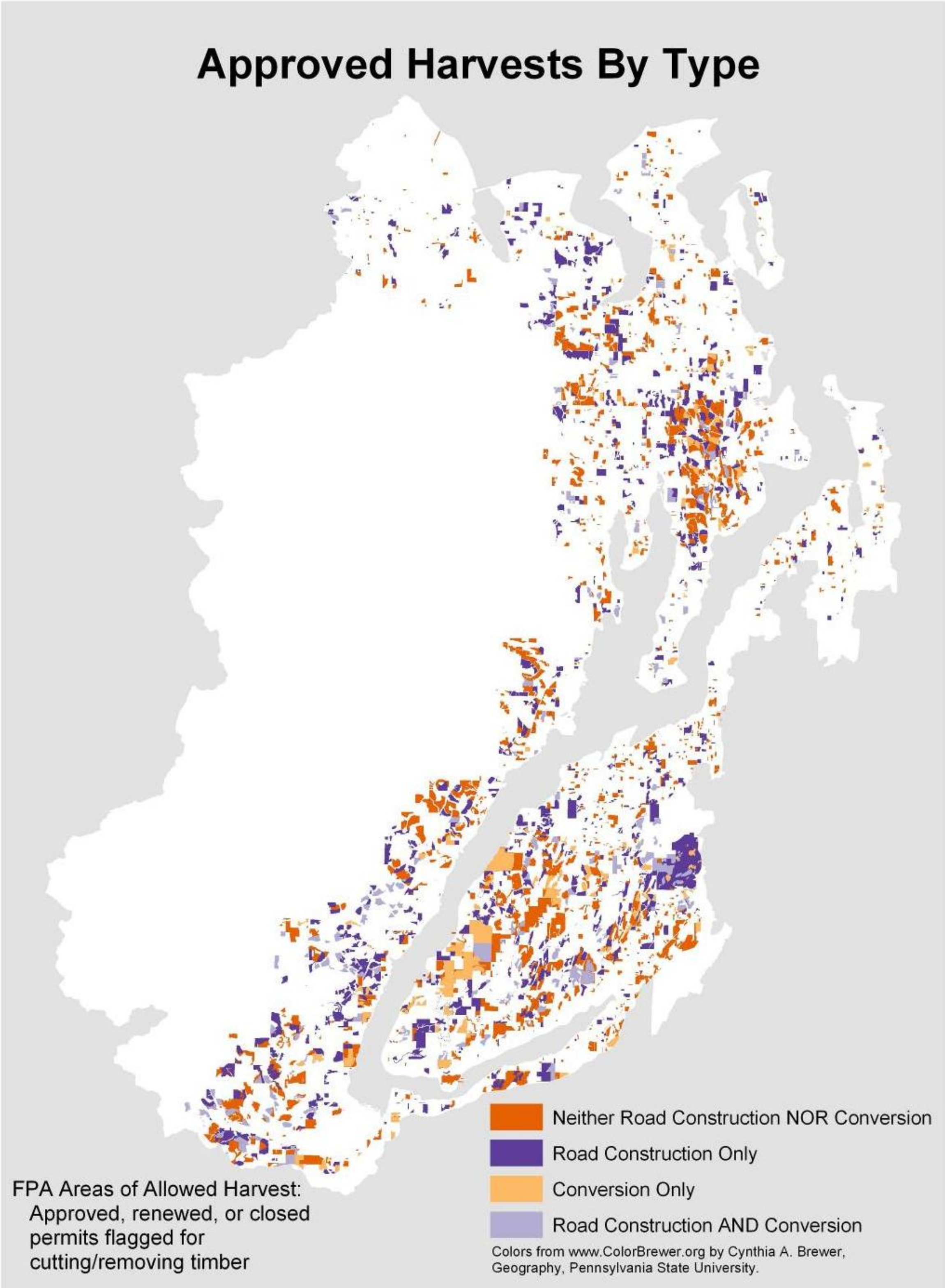
Here, the forest harvest permit applications flagged as road construction permits are shown.



Here, the forest harvest permit applications flagged as both conversion and road construction are shown.

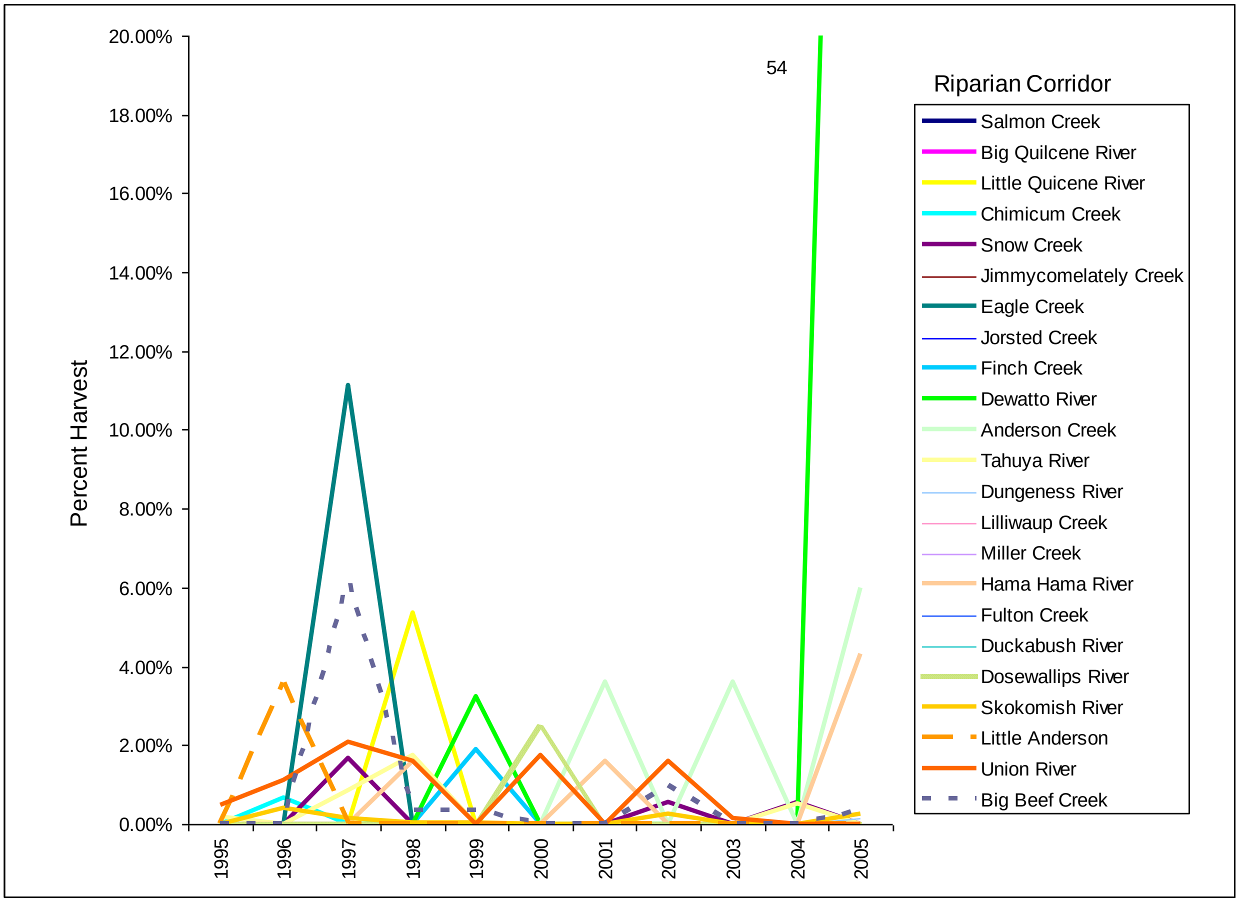


Here, the forest harvest permit applications that were not flagged as road construction nor flagged as conversion, are shown.

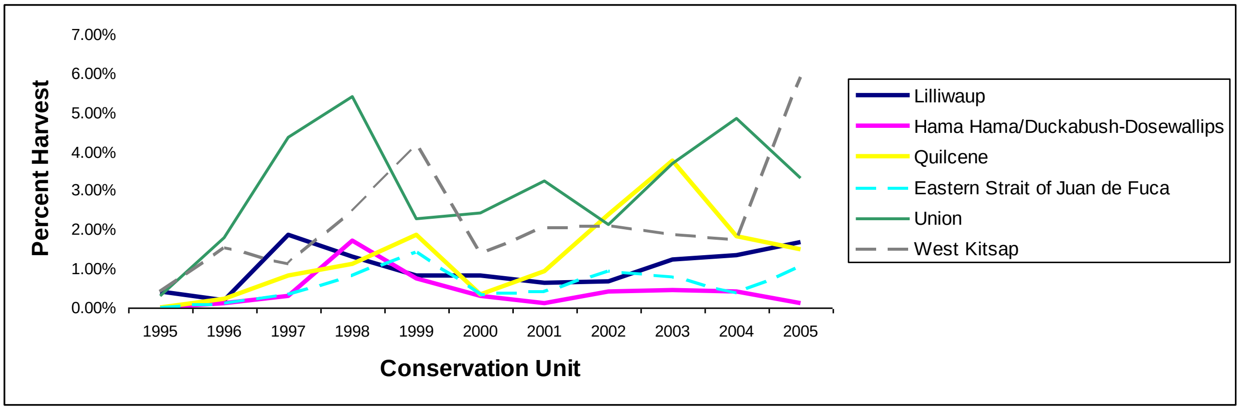


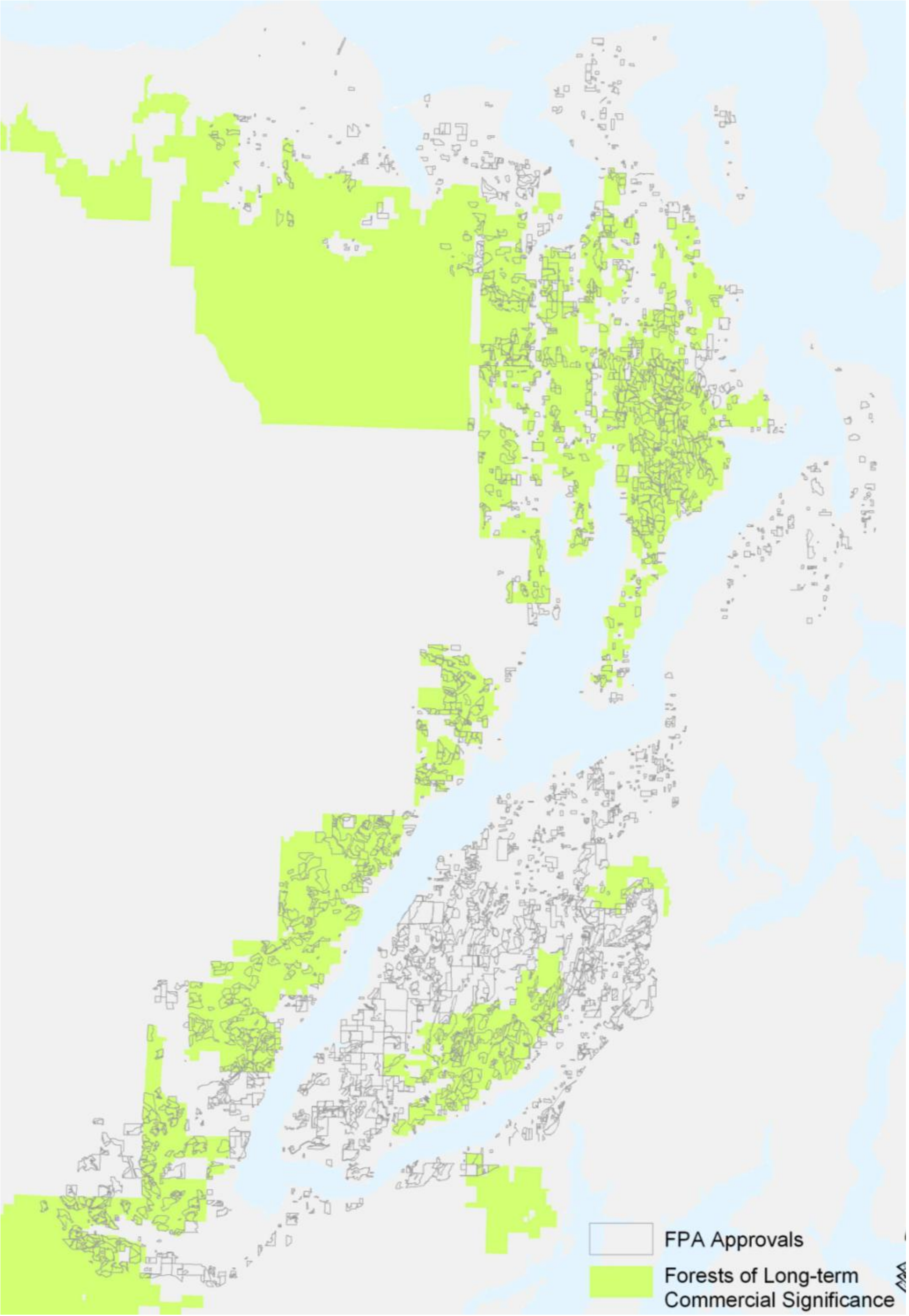
Here, the forest harvest permit applications are shown by type to get an overall view of what was happening in the ESU over the time period.

While the maps shown previously give a good overview of the whole ESU and a good comparison of basins within the ESU, it was also important to look at more localized effects on summer chum riparian corridors. To do that, the data were clipped to the riparian corridor polygons (see the *analysis units* section for a description of these) and an average amount of permitted forest harvest within each riparian corridor was calculated. For this exercise all of the permit types were included. The results are shown in the graph, below.

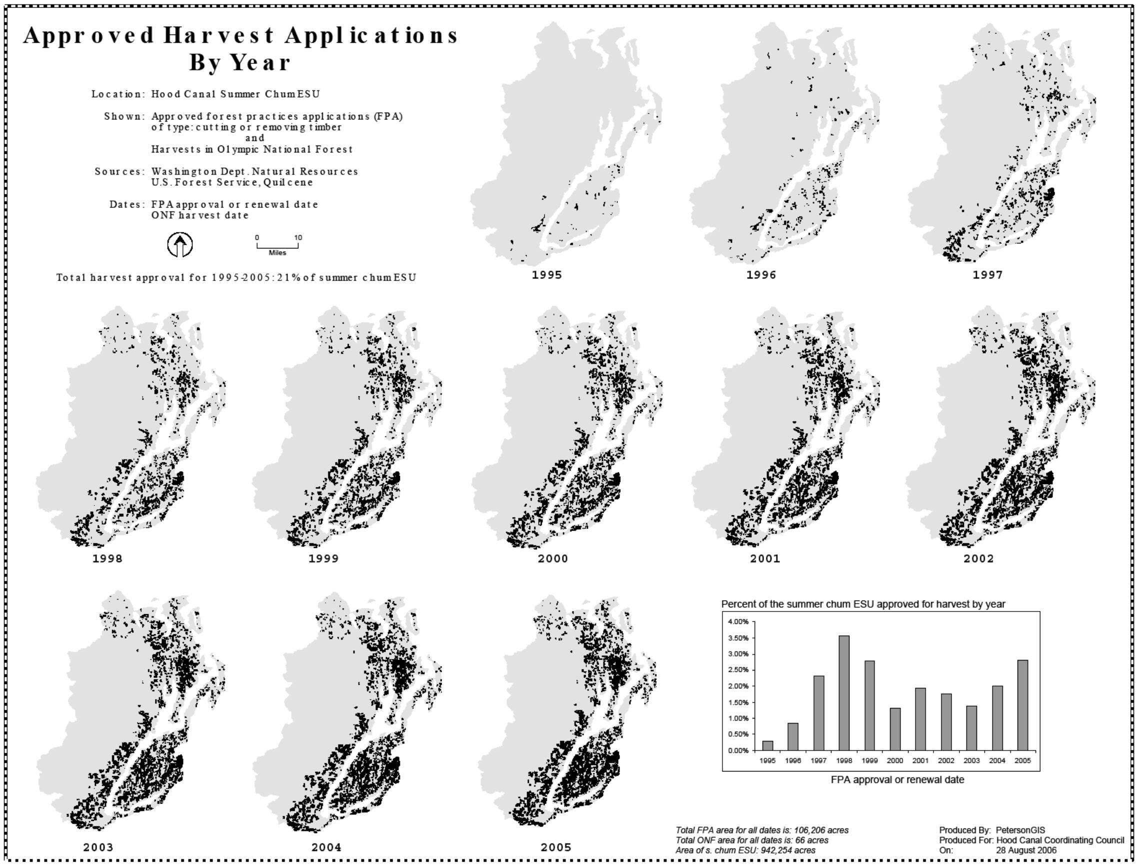


The data were also intersected with the conservation units (see the *analysis units* section for a description of these) in order to compare the conservation units in terms of harvest activities. The results of this calculation are shown in the graph, next page.


7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent Harvest
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Conservation Unit
Lilliwaup
Hama Hama/Duckabush-Dosewallips
Quilcene
Eastern Strait of Juan de Fuca
Union
West Kitsap



A question was raised about whether or not the forest practices applications overlapped with the “forests of long-term commercial significance,” which is a designation in the county zoning codes. The map above shows the results of this overlay. It showed that 48% of the forest practices applications were within the forests of long-term commercial significance.



A large format graphic showing harvests per year was developed to give an at-a-glance overview of the time series. A snap-shot of that graphic is shown above.

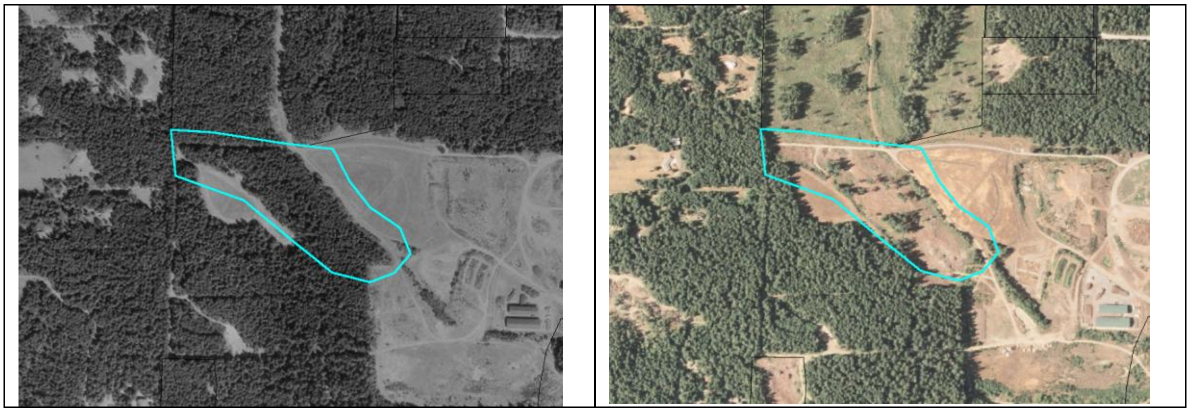
ERROR ANALYSIS

While the Olympic National Forest harvest database did contain polygons representing actual harvests (of which there were very few for the study's time period), the Department of Natural Resources forest practices applications represented only permitted areas, not actual harvests. In fact, the Department of Natural Resources does not maintain records on whether or not the harvest actually occurred after a permit was issued. Therefore, it was necessary to test whether or not those data could be used as a reasonable proxy for forest harvest – since this is what our study was assuming.

To test the assumption, an identification number was assigned to every forest practices application polygon. A random number generator was used to choose

50 random numbers within the range of the identification numbers. Those 50 polygons were examined at close-range within the GIS, overlayed onto 2006 1-meter color aerial photos and year 2000 black and white 2 meter aerial photos, to determine if a harvest had actually occurred.

For example, the forest practices application polygon shown in blue, below, is shown overlaid onto both the 2000 black and white 2 meter imagery and the 2006 color 1 meter imagery. This polygon was considered correctly identified in the error analysis as being a true harvest.



2000 aerial imagery **2006 aerial imagery**

Of the 50 polygons tested, 78% had clearly been harvested around the date assigned to them. This includes partial harvests where the whole polygon may not have actually been cut. When acreage of the polygons is factored in, only 70% of the total acreage of the 50 polygons were actually harvested.

CONCLUSION

The accuracy results were not as high as anticipated. Because free 1-meter aerial photos of good quality exist for this region, it is recommended that in the future the harvests are simply determined via heads-up digitizing (i.e., on-screen) of the aerial photos. This would not involve complicated aerial image analytical routines, rather, it is really just a matter of tracing the outline of perceived harvests by eye. The harvests are easily discernable from the aerial photographs. This could even be done with several vintages of aerial photographs such as:

2000 DNR black/white 2 meter
2003 HCCC black/white IRS imagery 5 meter
2006 NAIP color 1 meter
2008 NAIP color 1 meter (to be available in 2009)

in order to construct a time series. It should also be pointed out that this type of analysis can track forest change over time as it relates to harvest and is considered a historical analysis rather than a futures analysis.

Permits

Because the buildout studies (see the section titled *buildout studies*) showed that future development was not going to impact summer chum as much as originally anticipated (at least over the scale of the ESU, though local hotspots may still be an issue), the adherence to zoning regulations was a logical next step to test the buildout studies' accuracy.

Therefore, this permit study sought to determine whether or not variances to zoning regulations were occurring at a measurable rate and where. The permitting study was also developed as a means to detect hotspots in current development activities. It was determined that obtaining building permit data was the best avenue for gauging development trends due to exemptions and thresholds.

DATA INVENTORY

First, a data inventory of county permits and procedures was conducted to determine which ones could reliably track impervious surfaces. Included in this was an attempt to cull the data off of the internet via county permit tracking tools to see if it could be done easily. Some of the permitting data could be viewed online but it would not be cost-effective to obtain all of the permitting data this way.

DATA INPUTS

No spatial data existed to do this kind of analysis so data were culled from county spreadsheets of permitting data and joined to the GIS parcel layers in order to analyze them from a spatial perspective. Most of the analyses were based on the residential building permits data only.

> **Jefferson County:** spreadsheets of building permits and shoreline development permits for years 2003, 2004, and 2005. These were received from the Jefferson County Department of Community Development on 11/7/2006.
>
> **Kitsap County:** Shapefiles for years 2003, 2004, and 2005 of mobile home lots, mobile home parks, residential bulkheads, and other permit types received from the Kitsap County Department of Community Development on 7/26/2006.
>
> **Mason County:** Spreadsheets for years 2003, 2004, and 2005 of commercial, shoreline, building, and other permit types received from the Mason County Department of Community Development on 12/7/2006.

The data from the three counties, except mobile home permits in some cases, included square footage of first-floor impervious surface, permit-issue date, and location of permit via parcel number and address. The square footage of impervious surface records were not uniform across counties. In Jefferson County, for example, the information was located in a comment field whereas in Mason and Kitsap Counties it was located in an impervious surface field.

The data were gathered only after meeting with the community development departments of each of the counties. It was necessary to explain the reasoning behind the data collection and what would be done with it in order to obtain it. These data are not normally output in this manner and indeed, it is likely that nobody has looked at these data from a spatial perspective in these counties before this study.

METHODS

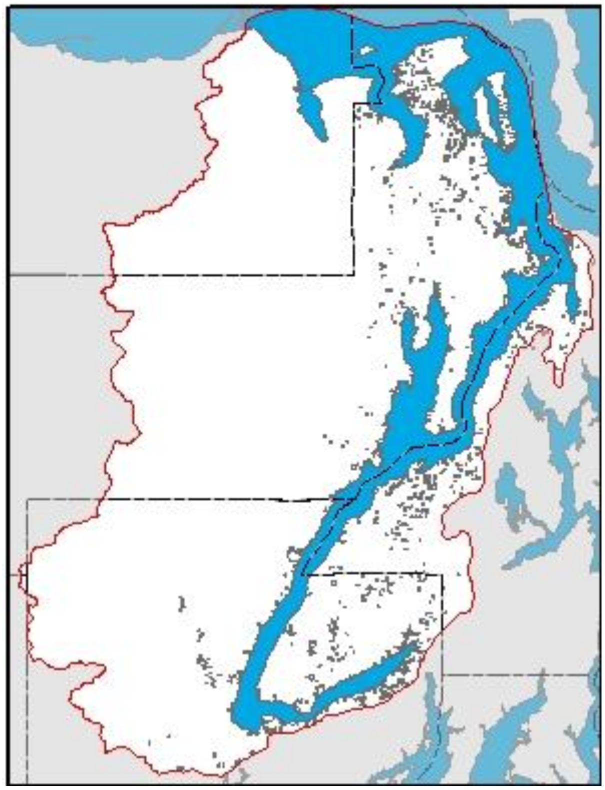
While the Kitsap County permit data were already in the form of GIS files, it was necessary to geo-locate the Jefferson and Mason County permits for use in the GIS. This was accomplished by joining each permit (represented by a row in a spreadsheet) to the digital parcels via the common field: parcel number. Where this failed to produce a match, the permit was located via address geocoding in the GIS. A small number of permits were dropped from the study when neither of the above methods produced a geolocated permit. These same procedures were carried out with the Kitsap County data by Kitsap County GIS personnel before they were sent to the HCCC.

Once a digital GIS permit layer covering all three counties was created, overlays with basins and conservation units made it possible to assign each permit additional location information pertaining to basin location and conservation unit location. Once that was completed the permits were reorganized into spreadsheets based on location and permit year.

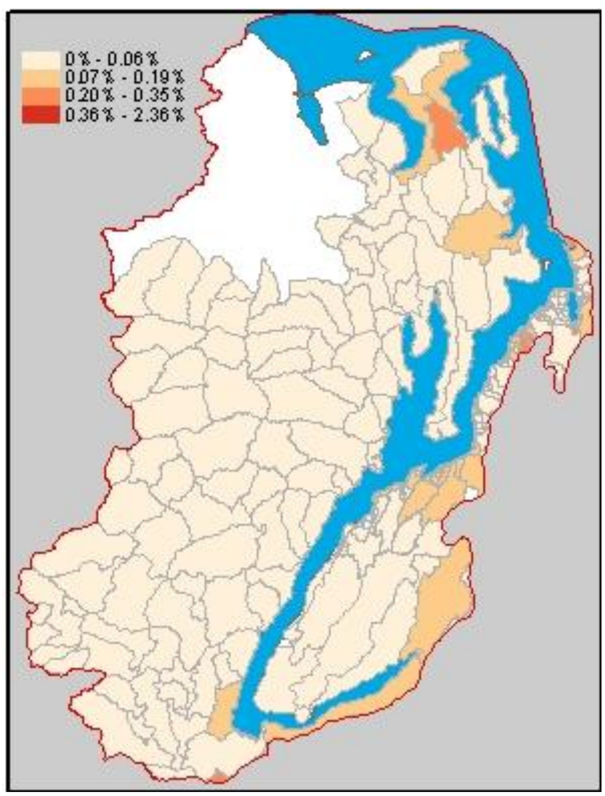
The spreadsheets were then cleaned up by removing duplications and permits that did not involve expansion of impervious surfaces (i.e. remodels, window replacement, re-roof, LP tank installations, etc.) For each sub-basin, totals were calculated of square footage, count, and percent of total square footage of basin area. Totals were also calculated for each county of: acres of impervious surfaces added, total project counts, median impervious surface expansion, and the median acreage of the parcel with a permit.

RESULTS

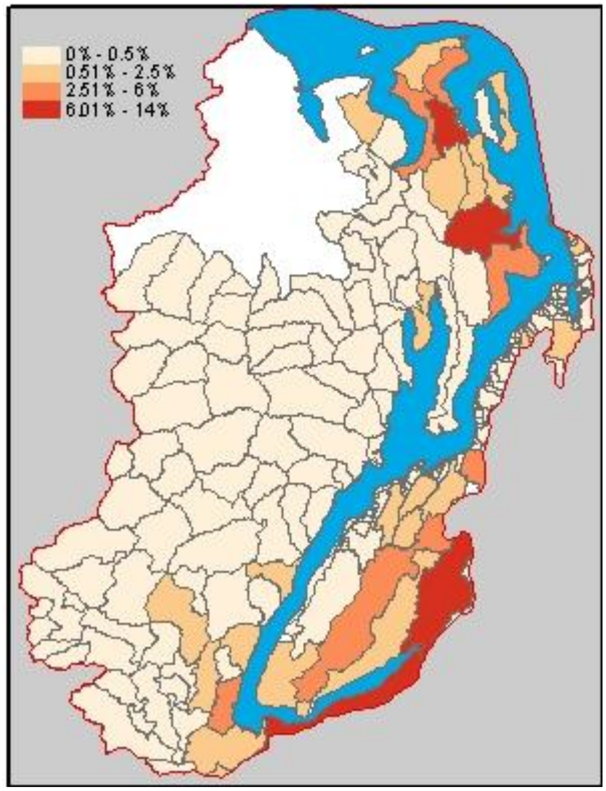
The parcels shown at right, in gray, are those that had permitting activity during the years 2003, 2004, and/or 2005.



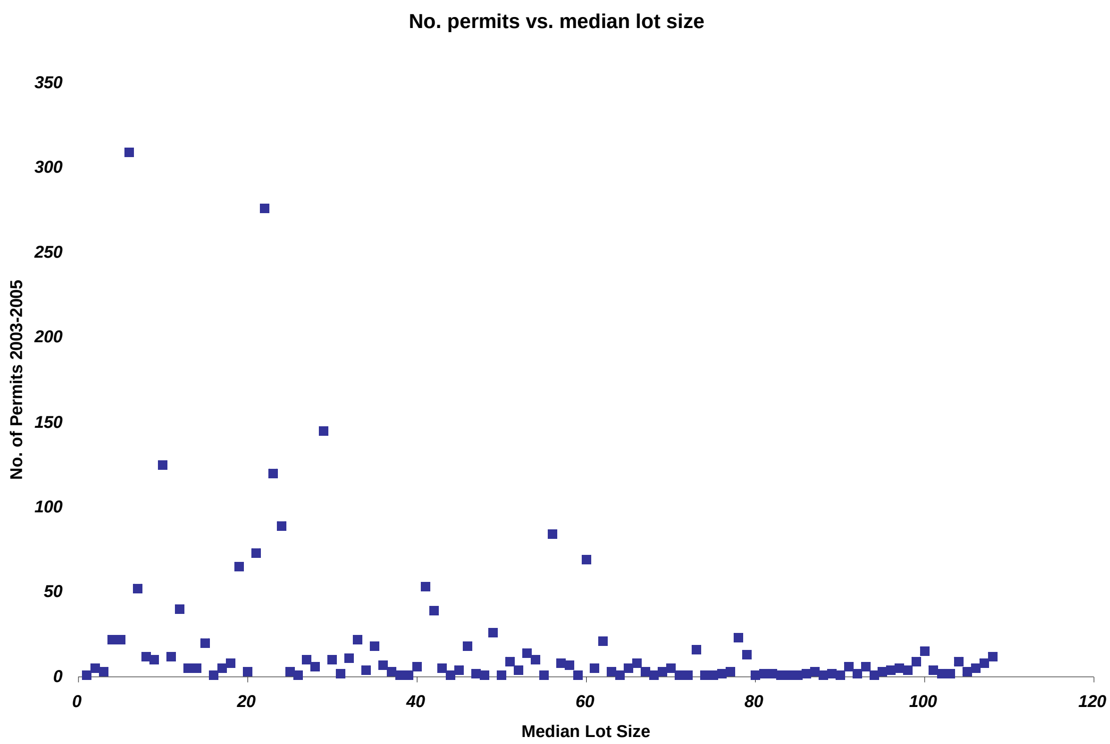
The impervious surface of the permits, summarized as a proportion of basin area, shows very low percentages due to the short 3-year timeframe of the datasets. Some concentration of permit activity is visible, however (see map at right).

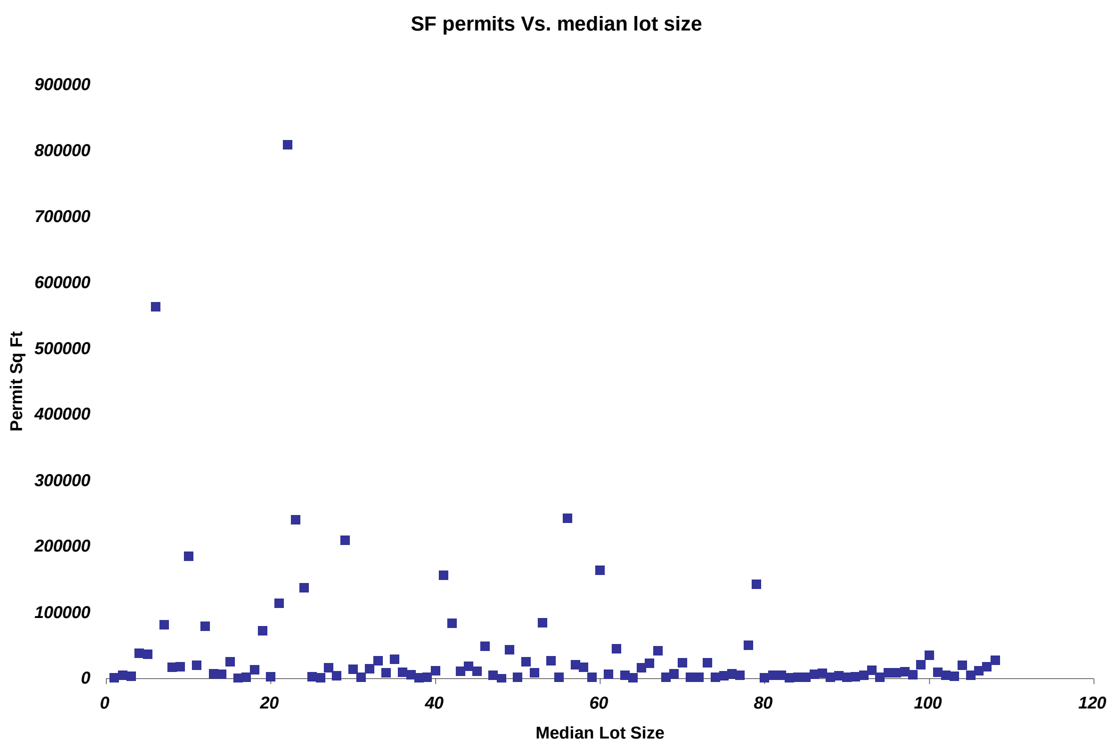


To see how the impervious surface by basin numbers compare with each other, the ratios in the map at right were derived by dividing the total impervious surface permitted in each basin by the total impervious surface permitted for the entire ESU. These results show where permitting activity was high or low relative to other basins.

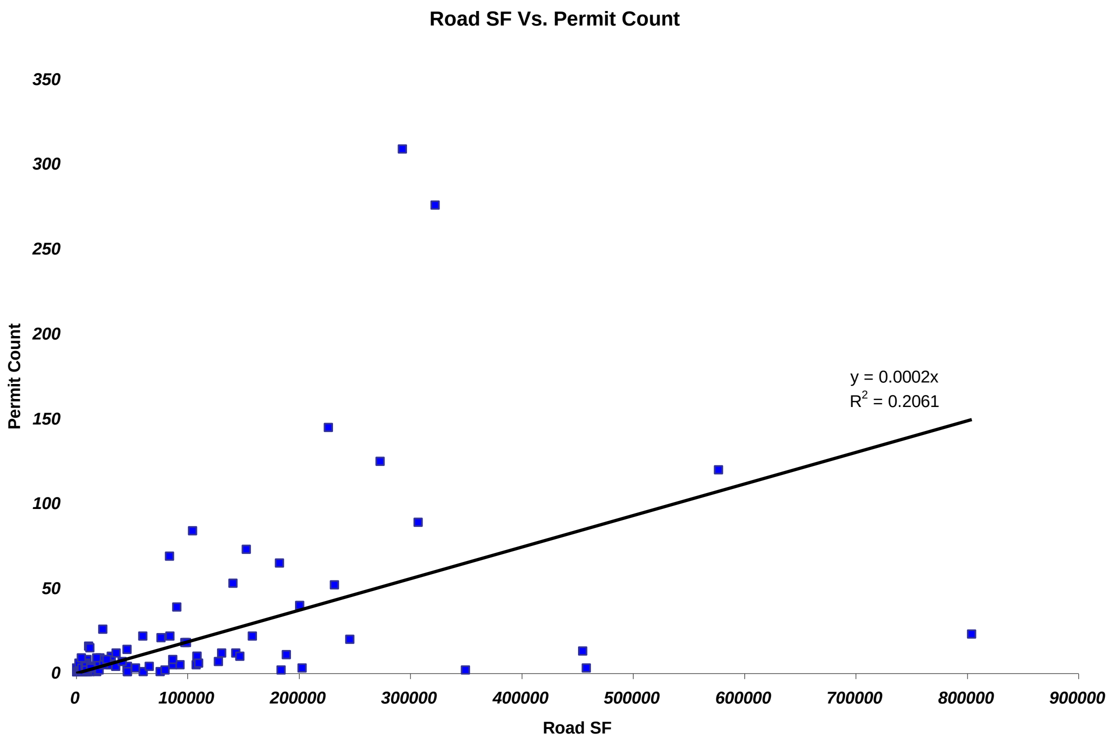


In addition to the map visualizations, several analytical avenues were pursued to determine if there were correlations between permitting and other variables. The lot size of permitted parcels showed little to no correlation with number of permits issued or amount of permitted impervious surface. See graphs, next page.

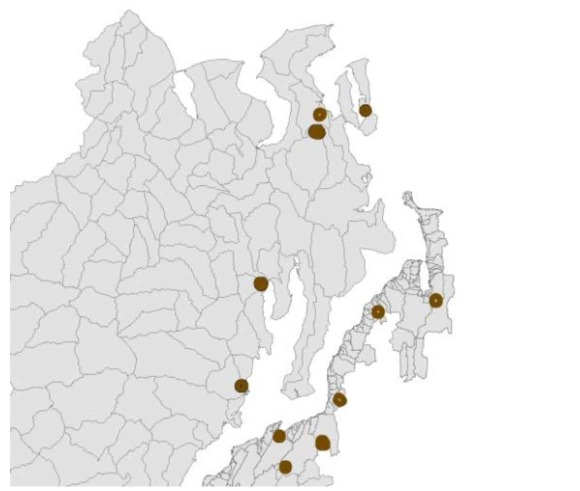
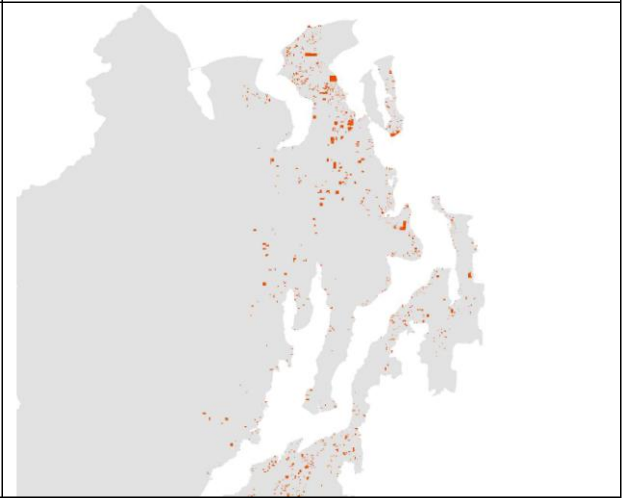

No. permits vs. median lot size
No. of Permits 2003-2005
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
Median Lot Size


SF permits Vs. median lot size
Permit Sq Ft
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
0
20
40
60
80
100
120
Median Lot Size

Similarly, road density showed very little correlation with permitted parcels. See graph, below.



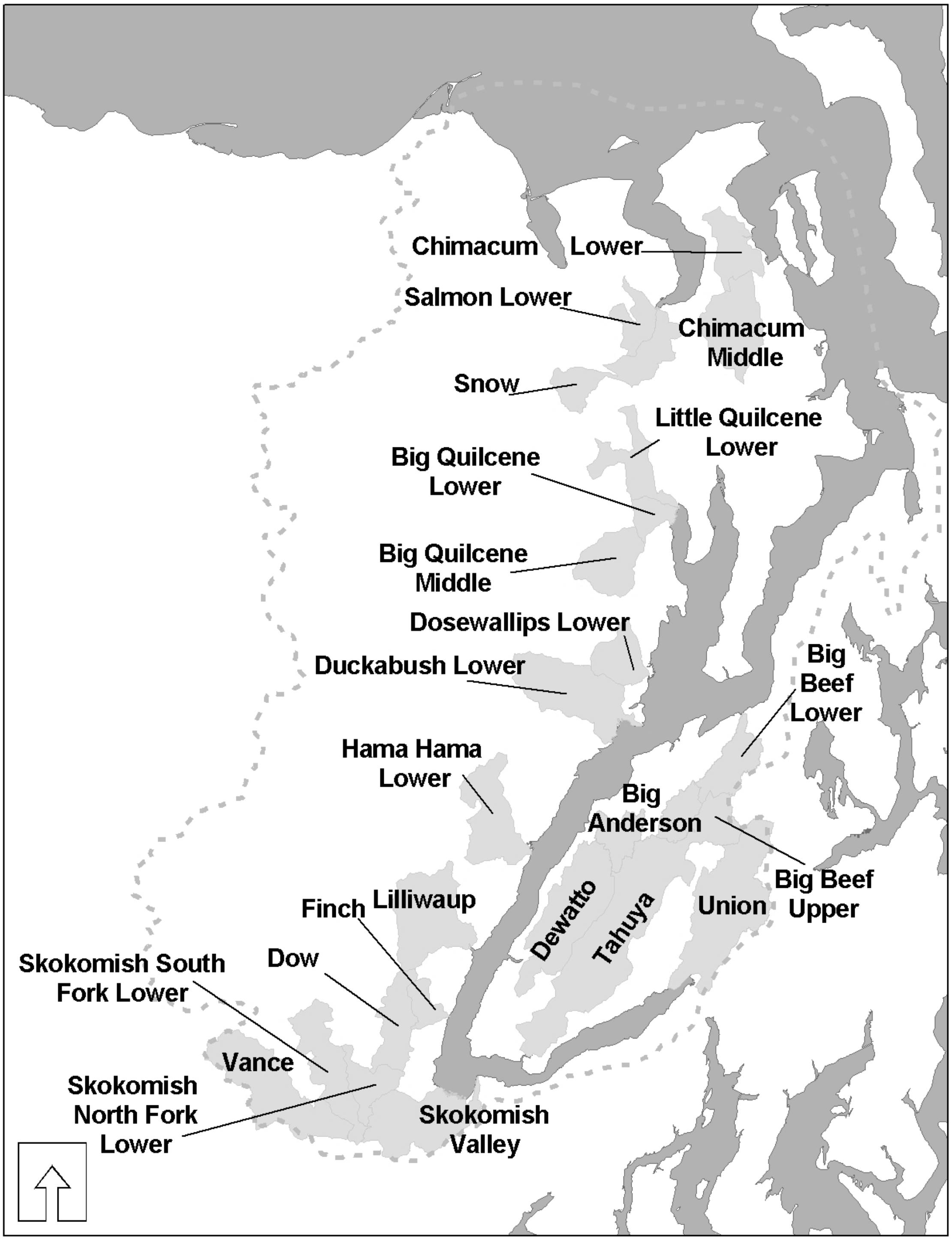
A school proximity analysis was also conducted to determine if permitting activity might be concentrated around schools. At the time of this study school data were only available for Jefferson and Kitsap Counties so the analysis was confined to those two counties. Some correlation was found. Buffers around the schools to ½ mile were created and the permits within those buffers were quantified (see maps, next page).

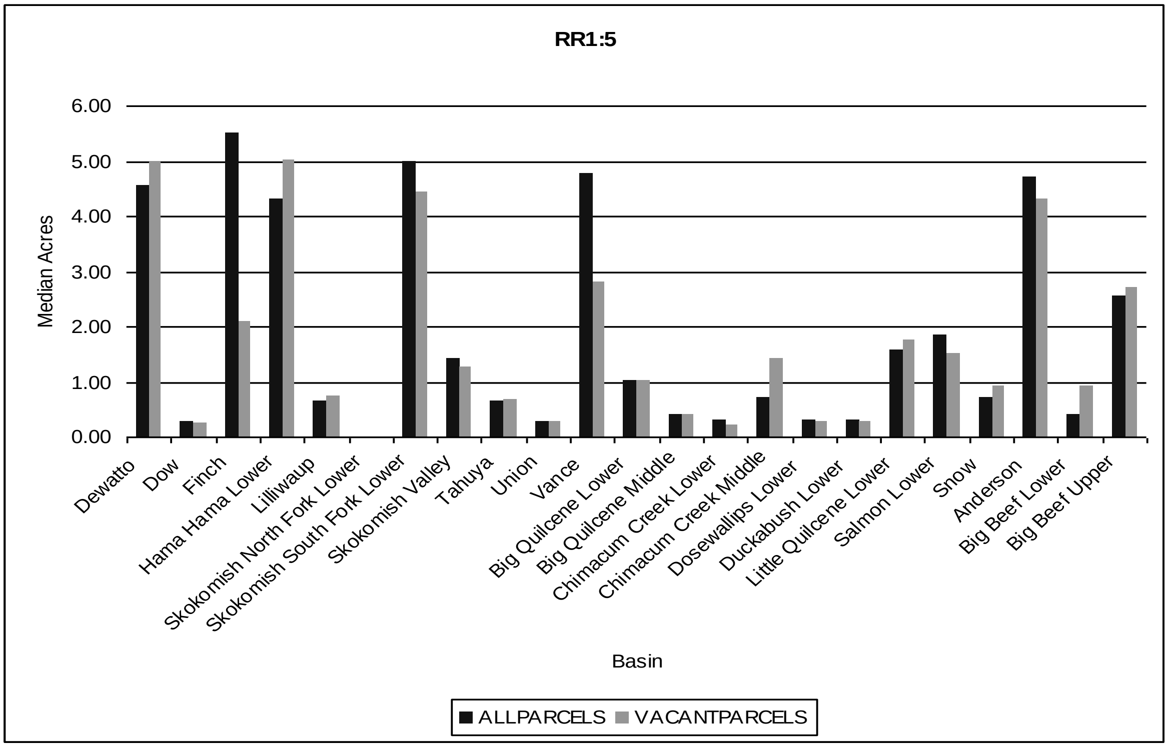
½ mile school buffers:	Permit Locations 03-05:
	

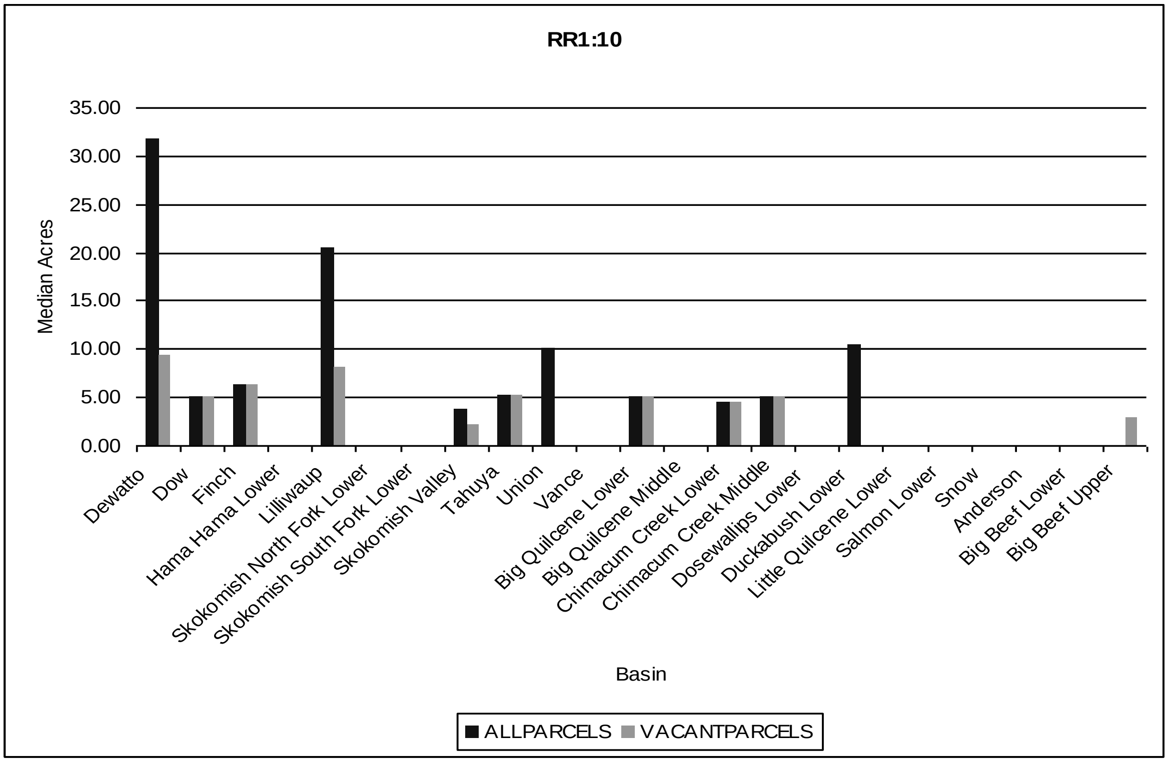
The following table shows the analysis results.

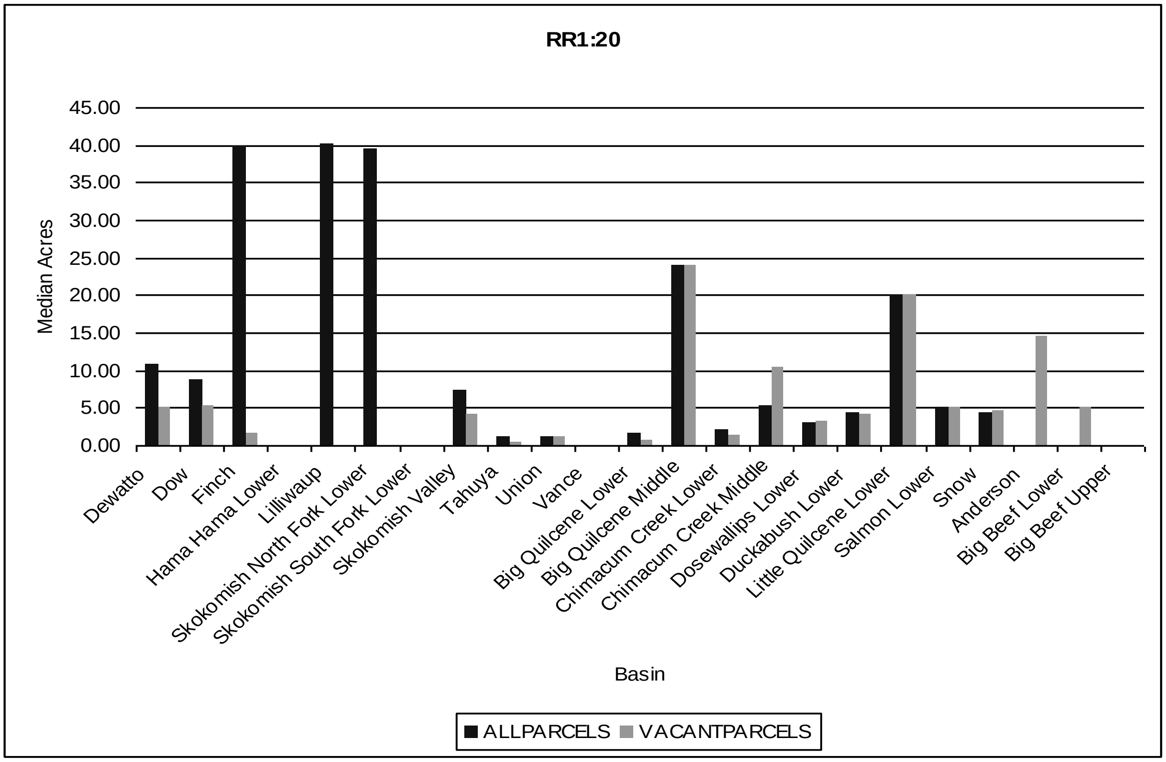
		Kitsap County	Jefferson County	Both Counties
pb	Permit Sq. Ft. in buffers	362516	275452	637968
po	Permit Sq. Ft outside of buffers	1584088	3753090	5337178
b	Buffer Sq. Ft.	190337776	152660896	342998672
a	Analysis area Sq. Ft. excluding buffers	4422143310	7527589446	11949732756
pb/b	Percentage of permits proximal to schools	1.90%	1.80%	1.86%
po/a	Percentage of permits not proximal to schools	0.036%	0.050%	0.045%

During the course of these investigations an ancillary question arose regarding lot sizes within residential zones. Parcels within each of the three most common residential zone-types (1 dwelling unit, or d.u., per 5 acres, 1 d.u. per 10 acres, and 1 d.u. per 20 acres) were isolated and their median acreage computed by basin. The results show that for most basins, the median lot size within the residential zones is actually lower than the zone requirements. This is significant due to the fact that building can occur on a lot that is smaller than its zone as long as the lot is already platted (except in cases where the lot does not meet other requirements such as slope stability, narrow lot, etc.). Furthermore, these results hold true regardless of whether all parcels are included in the analysis or just vacant parcels. All summer chum basins were included in the lot size analysis. See below for the basin names and their locations along with the graphs showing the results.




RR1:5
Median Acres
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Dewatto
Dow
Finch
Hama Hama Lower
Lilliwaup
Skokomish North Fork Lower
Skokomish South Fork Lower
Skokomish Valley
Tahuya
Union
Vance
Big Quilcene Lower
Big Quilcene Middle
Chimacum Creek Lower
Chimacum Creek Middle
Dosewallips Lower
Duckabush Lower
Little Quilcene Lower
Salmon Lower
Snow
Anderson
Big Beef Lower
Big Beef Upper
Basin
ALLPARCELS
VACANTPARCELS

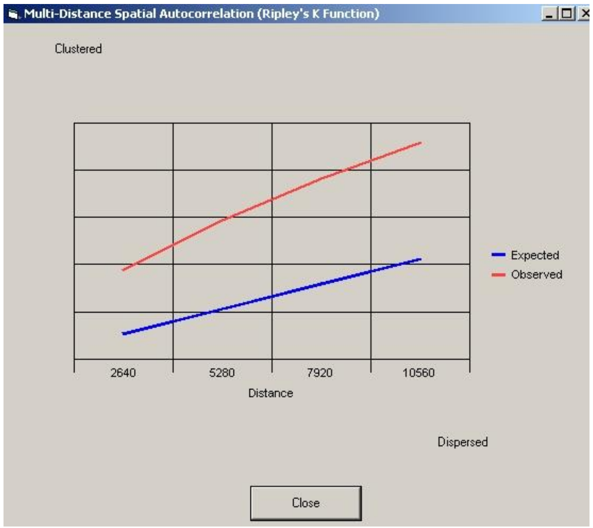

RR1:10
Median Acres
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Dewatto
Dow
Finch
Hama Hama Lower
Lilliwaup
Skokomish North Fork Lower
Skokomish South Fork Lower
Skokomish Valley
Tahuya
Union
Vance
Big Quilcene Lower
Big Quilcene Middle
Chimacum Creek Lower
Chimacum Creek Middle
Dosewallips Lower
Duckabush Lower
Little Quilcene Lower
Salmon Lower
Snow
Anderson
Big Beef Lower
Big Beef Upper
Basin
ALLPARCELS
VACANTPARCELS

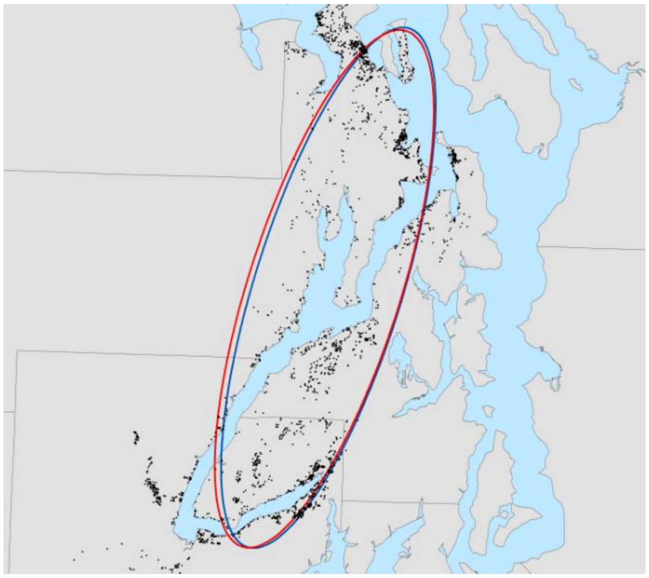


HOTSPOTS

A statistical analysis of the permitting data was also performed in order to determine if spatial clustering was present in the data and if so, where those clusters are.

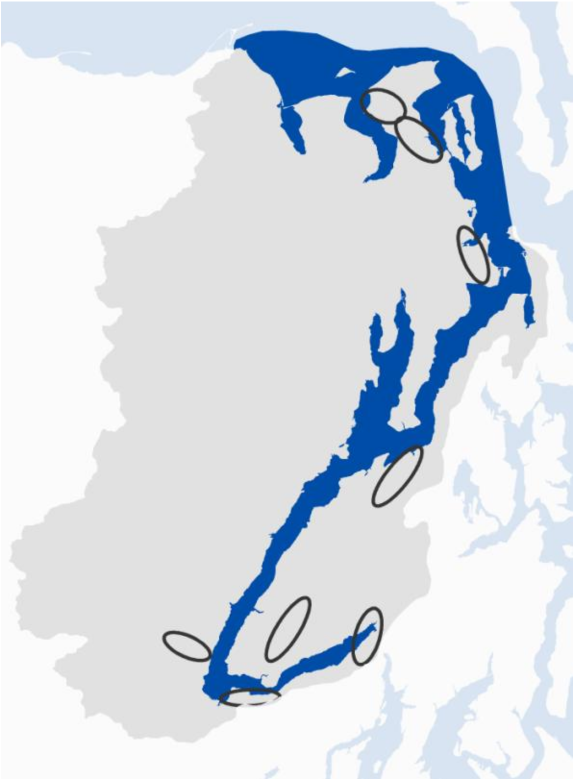
Using the multi-distance spatial autocorrelation test (Ripley's K Function) showed that at every distance measured, the permit points are clustered more so than expected, given the study area and number of points. The graph at right shows the output for the multi-distance spatial autocorrelation test with distances in feet (0.5 mile, 1 mile, 1.5 miles, 2 miles):





Using a simple directional distribution algorithm (standard deviational ellipse), the permits were measured to see if they have any directional trend as a whole. The permit data were fed into the statistical tests as points, meaning that every residential permit is represented by a point in the center of its parcel. The map at right shows the results. The red circle represents the directional ellipse when no weight is specified in the algorithm, while the blue circle represents the ellipse derived when the amount of impervious surfaces associated with the permits are used as a weight. Both are calculated using one standard deviation from the mean center as the distance parameter.

From this, we can see that the ellipse direction and scale does not significantly change whether or not the impervious surfaces are used in the algorithm. Most of the points contain about the same amount of impervious surface (i.e., most new homes have similar amounts of impervious surface) and those that are anomalous do not seem to alter the overall trend significantly. This conclusion could be tested via comparison of kernel density estimates if needed, but was not deemed necessary at the time the statistics were calculated.



Smaller clusters were identified via Nearest Neighbor Hierarchical spatial clustering (NNH). The location and size of the resulting clusters varied somewhat depending on input parameters but overall show the same general trends. After several runs of the data through the NNH algorithm, it was determined that weighting the features based on their impervious surface amounts produced practically the same ellipses as when the algorithm was run without weighting the points. A 90% confidence level (meaning that there is only a 10% chance that the clusters are a result of random clustering) was decided upon. The Kitsap points were run through the model separately from the Jefferson/Mason points in order to get rid of any problems that the Hood Canal void might cause in the NNH analysis. The minimum number of points for a cluster was set at 10. The results are shown in the map above, right.

We see here that residential permitting for the years 2003, 2004, and 2005 is clustered around the following major summer chum streams: Chimacum, Big Beef, Tahuya, Union, and Finch. To be more specific clustering occurs:

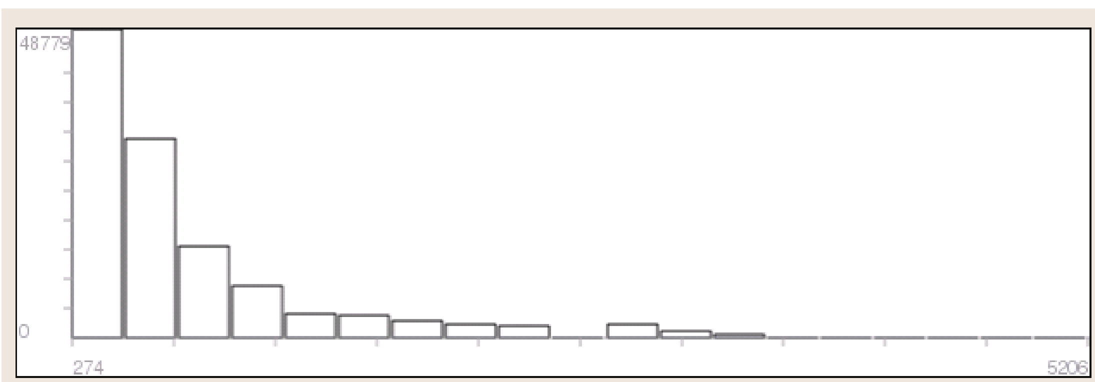
Around the Union River estuary
Along Finch Creek beginning at the mouth
Along Big Beef Creek beginning at the mouth
Along the shoreline immediately East of the Skokomish River
Along Chimacum Creek, upland of the mouth

Another statistical analysis was conducted to determine how far, on average, the permits are from streams. In this case just year-round streams were input. The answer was: 604 feet. To arrive at this answer, the distance from each permit point to the closest stream cell was computed. A Euclidean distance grid was created with a hydrology raster dataset, then multiplied to the permit point grid so that distances were assigned to the permit pixels while no distance (0) was assigned to the "no data" cells.

Statistics on the distance-to-stream data for all permit cells are as follows:

Total permit pixels: 123,086
Min distance = 0 feet
Max distance = 5,012 feet
Mean distance = 604 feet
Standard Deviation = 673 feet
Variance = 452,395
Variation Coefficient = 111%

The histogram of the distance to stream table is shown below:



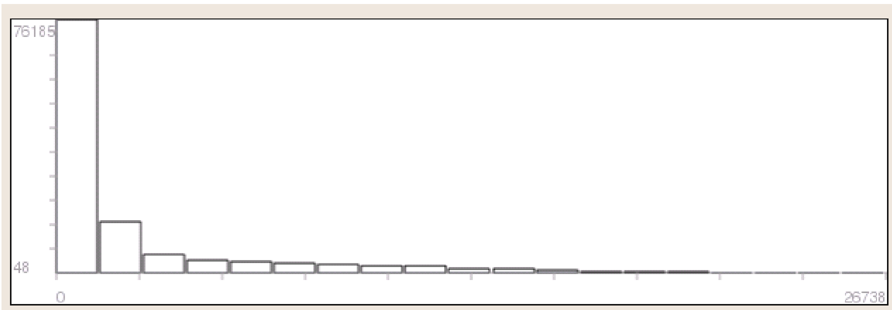
where the distance to stream is on the horizontal axis in feet and the frequency is on the vertical axis.

The question then became: are there so many streams that most pixels are near a stream in general or is it really a special feature of the permit data?

To answer that question, one random grid was produced using the same number of pixels as the permit grid but placed randomly around the study area. The same Euclidean distance grid of hydrology was used to figure out how far each randomly placed pixel was from a stream pixel. The results of the random analysis are:

Total Cells = 123,086
Minimum Distance = 0 feet
Maximum Distance = 26,7239 feet
Mean Distance = 2,693 feet
Standard Deviation = 4,325 feet
Variance = 1.9e +07
Variation Coefficient = 161%

The histogram of the distance to stream table for the random pixels is shown below:

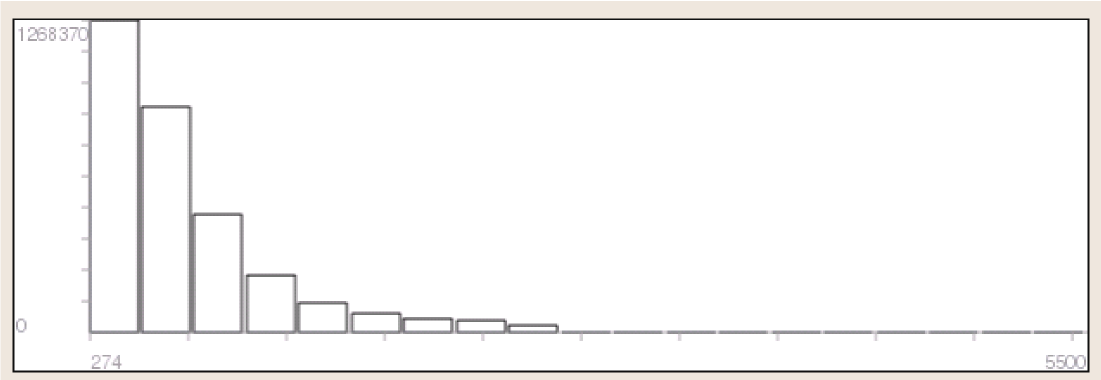


Statistics for the impervious surface data that the HCCC had (year 2003, 5 meter impervious surface grid) were also computed as part of this exercise for comparison purposes. For the average distance to year-round streams statistic the answer was 6.15 feet, measured with a Euclidean distance grid in the same manner as the permitting data.

Statistics on the distance-to-stream data for all impervious surface cells are as follows:

Total impervious surface pixels: 280,429,820
Min distance = 0 feet
Max distance = 5,485 feet
Mean distance = 6.15 feet
Standard Deviation = 80 feet
Variance = 6,401
Variation Coefficient = 1300%

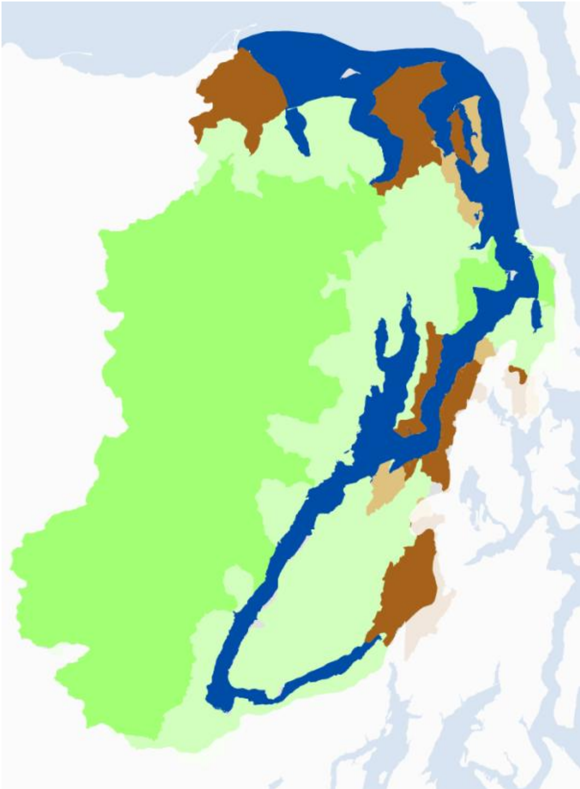
The histogram of the distance to stream table is shown on the next page.



No random grid was generated due to the large number of points/cells that would have to be randomly placed.

GI* Statistic

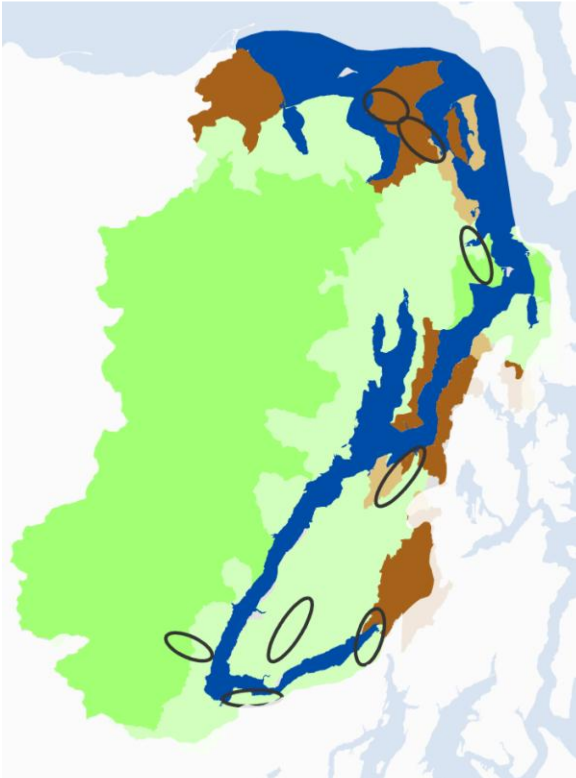
This statistic uses a summary of the data, summarized into polygons, to determine clustering based on a distance value. The impervious surfaces data, being too large to do any NNH analyses on them, were summarized by watershed instead. Each watershed (count = 294) is assigned a “percent of watershed that is impervious surface” number. That is the number that goes into the GI* Statistic. Using a distance value of 5 miles, or 26,400 feet, the result for impervious surfaces clustering is shown at right.



GI* for Permits

Unfortunately, the same process applied to the permitting data, regardless of changes to the distance parameter does not produce favorable results. There are two likely reasons: #1 Because the permitting data contain such small numbers of permits and thus small amounts of impervious surface, most of the basins show 0 percent impervious surface and the ones that are above 0% are very small percentages. #2: Edge-effects most likely artificially created “hotspots” in the Northern part of Kitsap County. The results of this analysis are therefore not shown here.

Overlay results of permit hotspots and impervious hotspots



Another way to compare the two results is simply to overlay the permit clusters onto the impervious surface clusters (shown at right). Because impervious surfaces reflect 2003 data and permit clusters reflect 2003-2005 permitting activity, this gives us a baseline of conditions/hotspots on a basin scale and a finer-tuned picture of hotspot locations in the years following that baseline. From this picture we start to see that permitting hotspots were not confined to existing impervious hotspots.

LONG-TERM MONITORING PROGRAM

This study showed that long-term monitoring of permitting activity with respect to impervious surface is feasible. Several methods are possible. For one, permits can be manually recorded off the internet sites for each of the counties on a daily or weekly basis. The benefit of this approach would be minimal-to-no timeexpenditure by county personnel. However, the manual copying of data from online databases to a project-specific database could introduce error and is laborious. Another approach is to request the information from the counties regularly in spreadsheet or GIS format. If this were put into practice, however, a plan for implementing it, including how to automate the data download and transfer procedure would need to be created with significant participation by the constituent counties.

No matter what the long-term strategy, it will be important to resolve some of the outstanding issues with the data. The first issue is that of parcel number changes. Parcel numbers can change under certain circumstance such as when a parcel is subdivided. Retention of the old parcel numbers when this occurs will facilitate any historical analyses that use data identified with parcel numbers. One method is to retain historical parcel databases and make them available to researchers and/or the public. Another is to update all associated parcel-number data when parcel numbers change. So in the case of permitting data, the permitting information keyed to a particular parcel number would be updated with the new parcel number. Two other changes of interest in county reporting systems would be the inclusion of impervious surface as a separate field (in Jefferson County) and the recording of impervious surface area associated with manufactured-home permits.

An entirely different approach to tracking impervious surface increases was also discussed. This would involve the digitization of buildings via orthophoto interpretation (either by-eye or via specialized software) on a yearly basis. This would necessitate the acquisition of high-resolution images of 18-inch or higher. Kitsap County already has a database created in this manner but it was based on 2005 orthophotos and is not slated to be repeated until 2010.

Protected Areas

An inventory of all of the protected lands within the summer chum ESU was created to detect where gaps in protection might be.

DATA INPUTS

Mason County parcels: dated 2/13/2007; landuse codes, owner names, and description fields
Jefferson County parcels: dated 11/7/2007; landuse codes, owner names (with special permission – not to be distributed)
Kitsap County parcels: dated 3/3/2008; with “land” table including landuse codes, and owner name
Public Land Database: 8/24/2006; data from CommEnSpace
Olympic National Forest: forest boundaries and administration types

METHODS

The data development process started with an examination of the Public Land Database. This database had similar goals and scale though had not been updated for a year. PetersonGIS met with CommEnSpace (now dissolved) to learn how the Public Land Database had been created. Similar methods were then applied to create the HCCC protected areas database.

The three parcel data layers were used to extract protected land parcels by means of a select/sort/search process. Specific combinations of owner names and landuses that would be considered “protected” were selected and input into the protected areas database. For example, a combination like “Kitsap County” and “parks” would warrant inclusion in the database.

The parcels were also assigned a single protection value in the database according to the Public Land Database protocol (U.S. National Gap Analysis Program adjusted for Vermont). The protocol is outlined on the next page.

Protection level on a scale from 1-4. U.S. National Gap Analysis Program definitions adjusted for Vermont (National Biological Survey Gap Analysis Program Handbook, version 1).

(1) An area with an active management plan in operation that maintains natural conditions and within which natural disturbance events are generally allowed to proceed without interference. The management objective has legal standing and cannot be altered at the discretion of the administering agency, organization, or individual. Examples; National Parks, Nature Conservancy Preserves, Audubon Society Preserves, Wilderness Areas, Forest Service Research Natural Areas.

(2) An area managed generally in a non-extractive way for its natural values, but which may receive uses that degrade the quality of the natural communities that are present. Management objectives are not legally mandated for biodiversity conservation, and such objectives may be subject to administrative discretion. Examples; State Parks, State Wildlife Management Areas with low intensity forest management.

(3) An area for which legal mandates prevent permanent conversion, but which is subject to extractive uses. Examples; non-reserved National Forest areas.

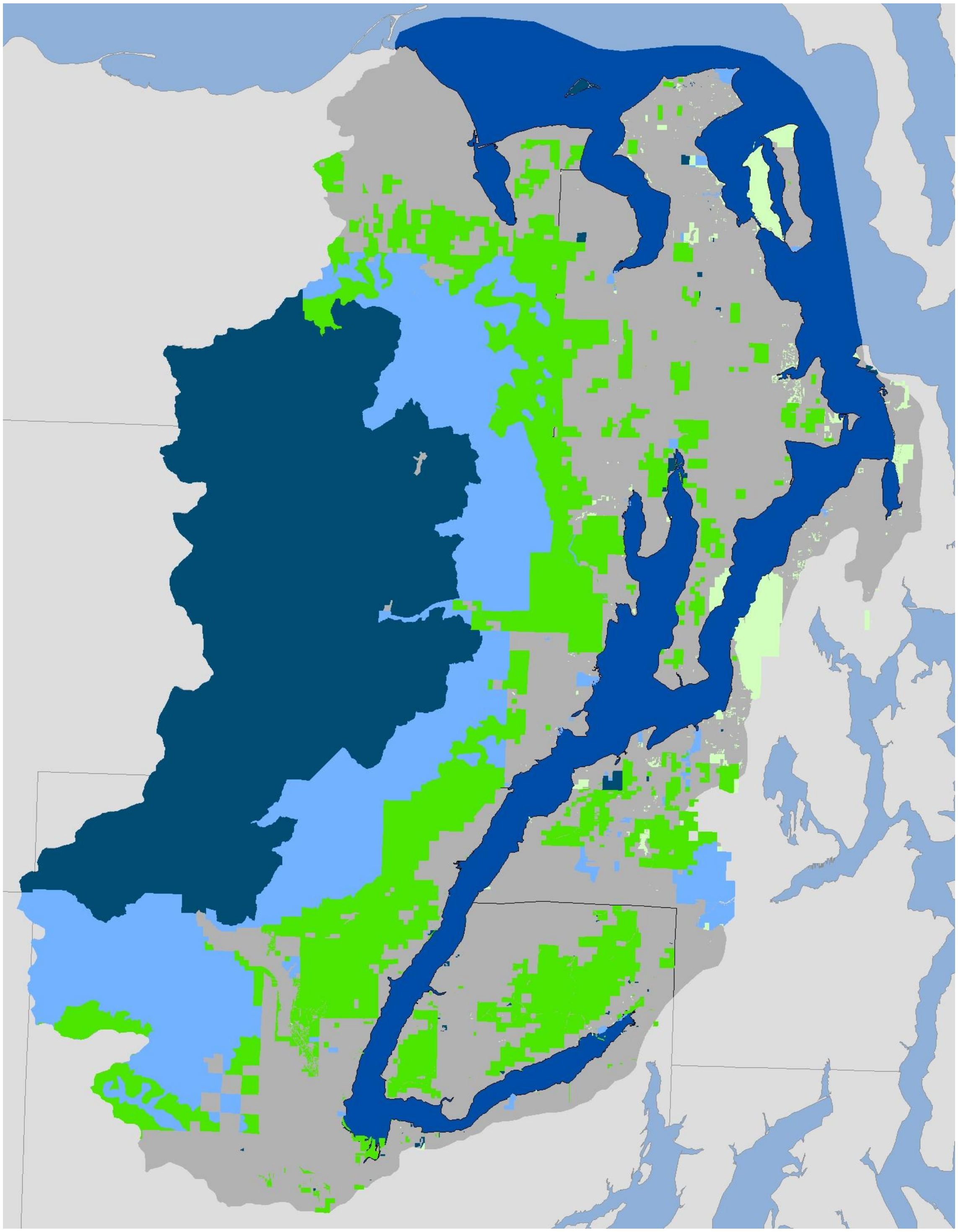
(4) Lands managed in ways that may preclude the holisitic maintenance of native plant and animal assemblages. Examples: Department of Defense lands, or privately owned lands not having deeded covenants for biodiversity conservation or not owned by organizations having a principal charter to manage for the long-term maintenance of native biological diversity.

The Olympic National Forest data were assigned protection levels using the same protocol. The two datasets were then made into feature classes and put into the same geodatabase to keep them together. Note that the protection levels were not double-checked for accuracy.

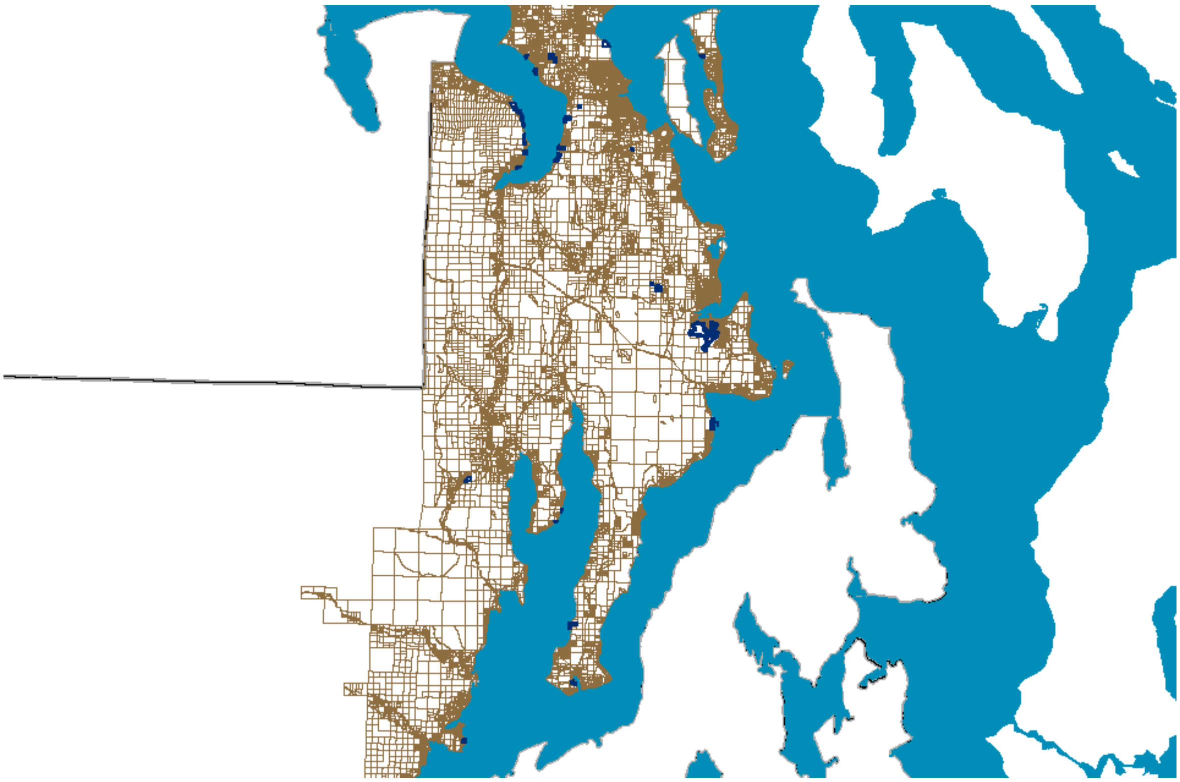
OUTPUT

The data were collected into a single geodatabase called ProtectedLand with two Feature Classes: OlympicNationalForestProtectionLevels, and ProtectedLandInESU. A layer file with symbology for the different protection levels was also created to facilitate easy loading into a GIS program.

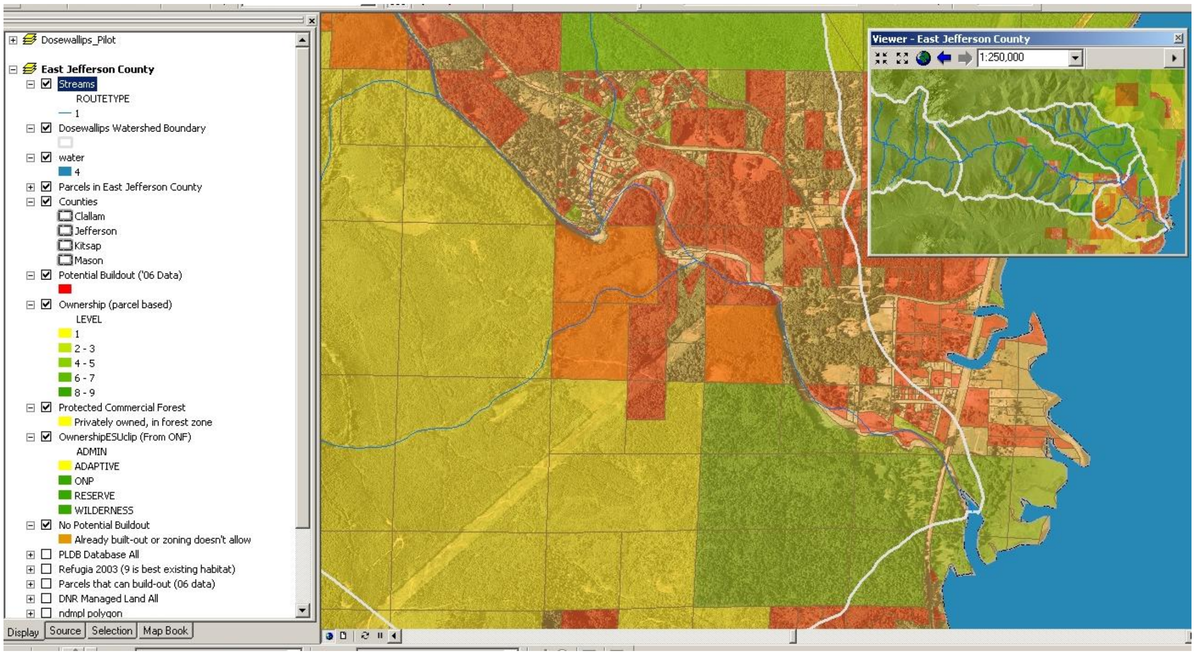
The Olympic National Forest data were kept in a separate feature class from the other protected land data because the two datasets overlap and there was no easy way of merging the two without loss of data. The layer file symbology for the four types is shown on the next page.



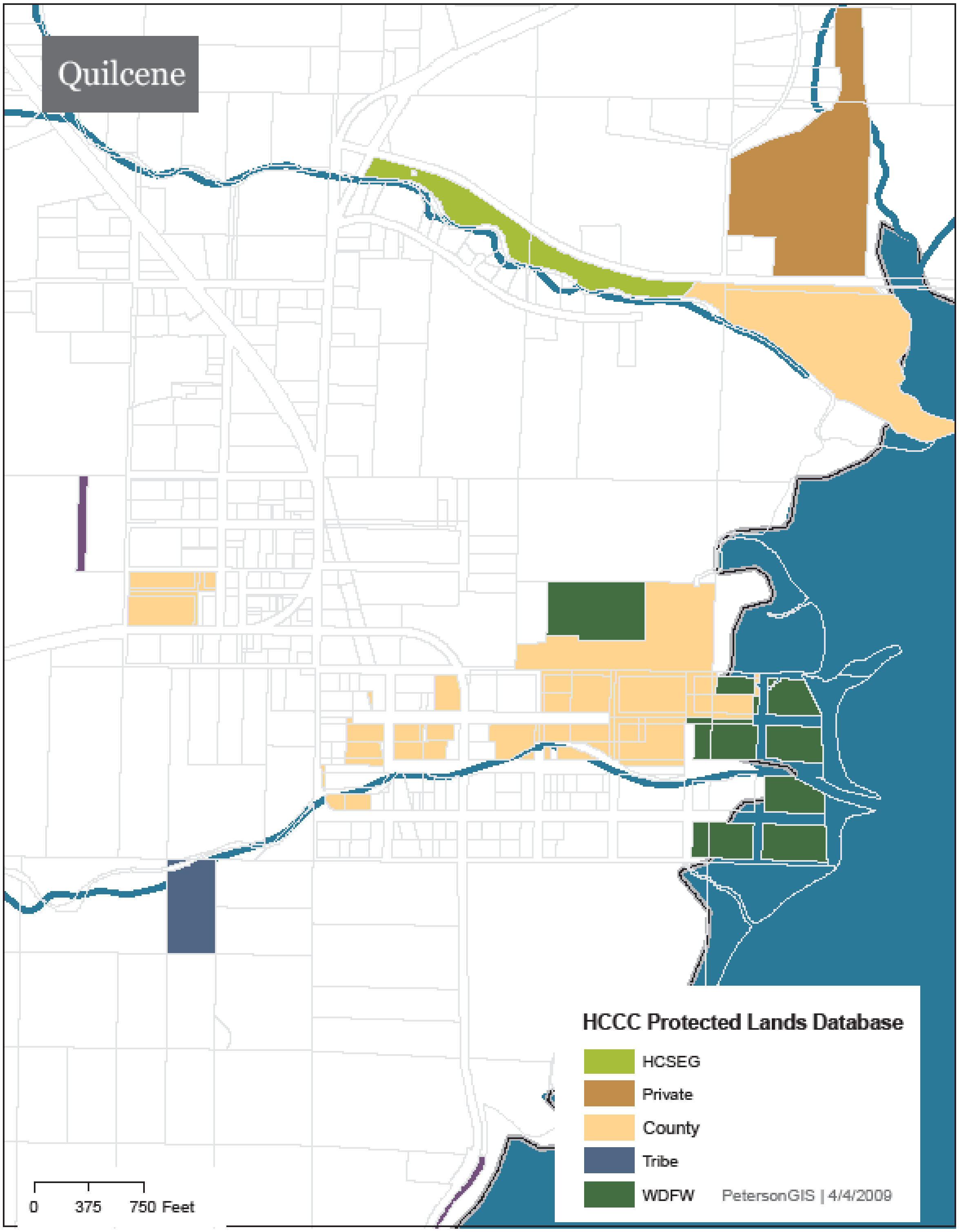
Potential PBRS (Public Benefit Rating System) properties were also identified but kept in a separate GIS file because they were somewhat unknown. These are all located in Jefferson County and were identified by their flag as landuse code 8110 which is "open space," though they are all flagged as "taxable" and have various owners ranging from individuals to commercial timber companies and others. There is no way to tell from the digital data whether or not all 110 identified parcels are PBRS (if the recorded agreement date is after the PBRS adoption then it is a PBRS parcel but this information is not in the digital database). These properties are shown outlined in blue, below.

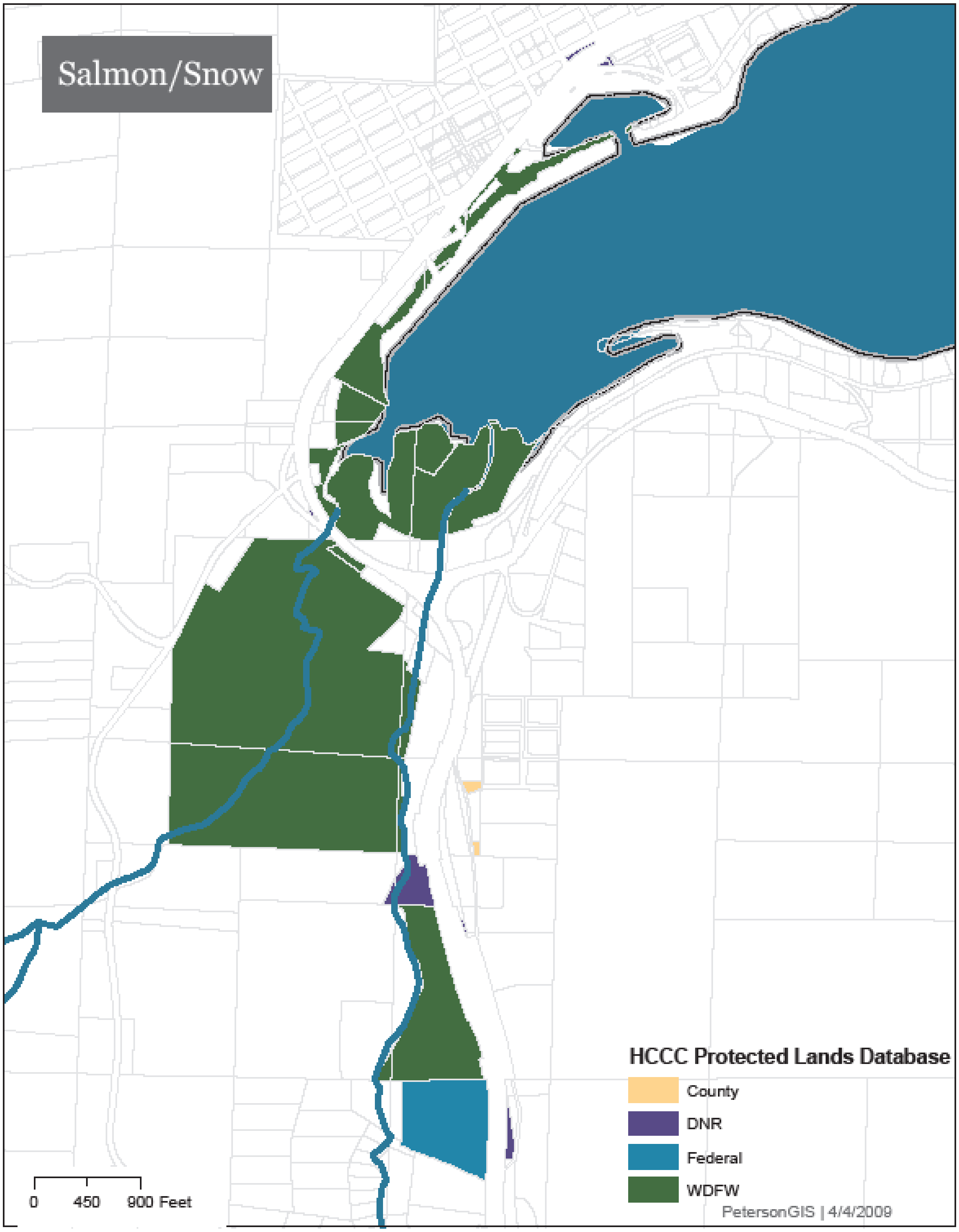


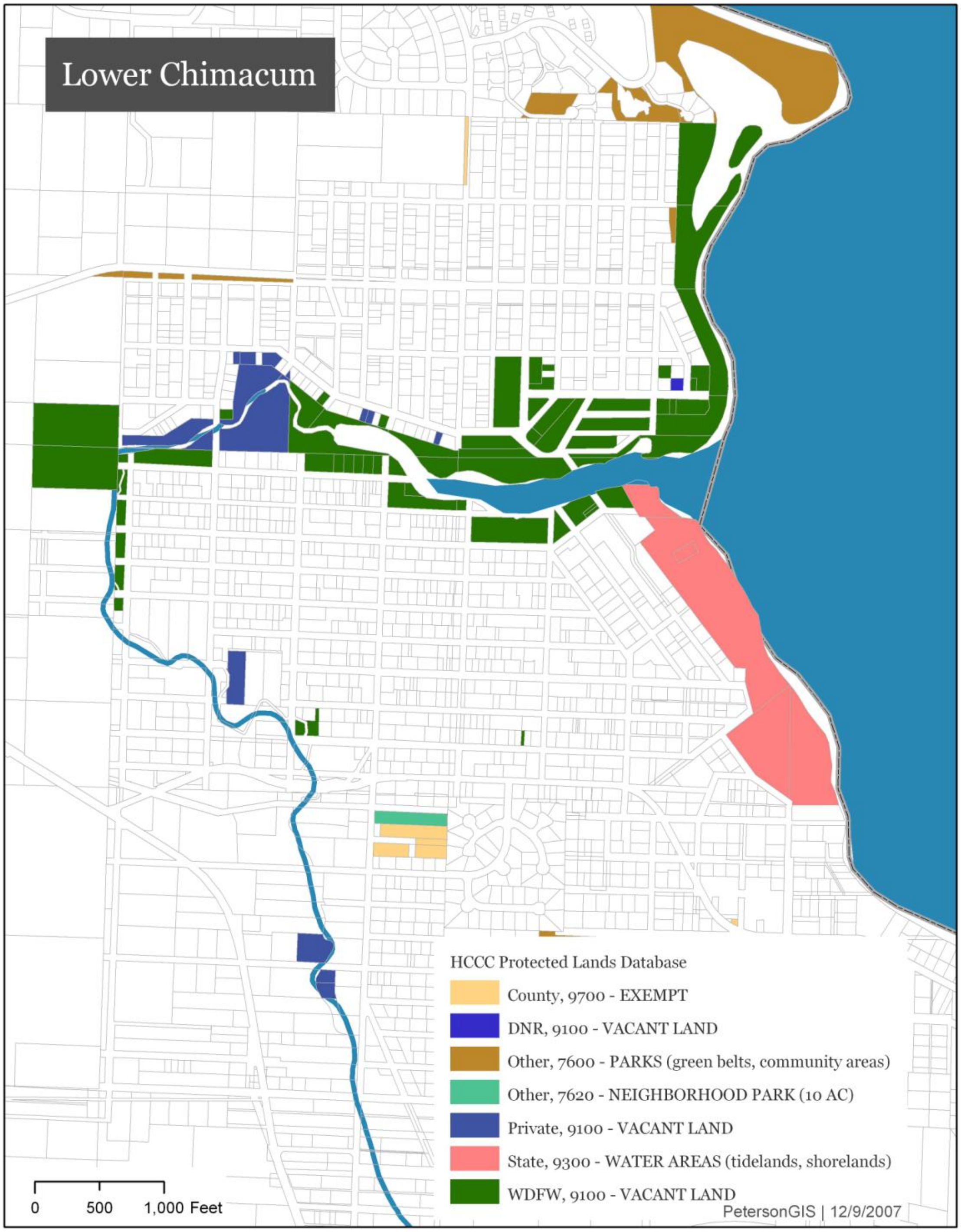
The screen shot on the next page shows how the protected lands (Ownership) are used in a GIS project along with other analyses and data to assess conditions at a parcel scale.



The maps on the next pages were created to show where the protected lands are within certain basins for inclusion in a grant proposal.


Quilcene
HCCC Protected Lands Database
HCSEG
Private
County
Tribe
WDFW
PetersonGIS | 4/4/2009
0
375
750 Feet


Salmon/Snow
HCCC Protected Lands Database
County
DNR
Federal
WDFW
0
450
900 Feet
PetersonGIS | 4/4/2009



FUTURE STEPS

These data need to be updated on a yearly basis to incorporate new acquisitions and changes in management. Since they are based on late 2007 and early 2008 parcel data they are already becoming obsolete. In fact, it was discovered that there were several property designation changes in the Lower Quilcene area that were not in the database when the Quilcene map (shown previously) was created. That portion of the database was updated on-the-fly for that particular map but it is anticipated that other locations will need updating as well. The data are only good so long as they are reasonably current. It is also recommended the database be updated to include dates of inclusion in the database so that an ongoing time series of protected lands can be created. Seeing and quantifying protected land increase or decrease over time would be a useful visualization and calculation.

Impervious Surfaces

The impervious surface data that were procured for use in the original buildout study (see the section titled *buildout studies)* and used subsequently in the next two buildout studies were based on 2003 5-meter Indian Remote Sensing and 30-meter LandSat imagery. The resultant impervious surface data were at a 5-meter resolution and met error accuracy standards. However, it was determined that a better resolution impervious surface dataset could enhance the buildout study and that, indeed, it could be possible to create one given new image data availability for the area. Therefore, it was decided that a new impervious surface dataset would be created.

DATA INPUTS

> **Imagery:** National Agriculture Imagery Program, 1-meter resolution, color, year 2006
> **Roads:** Washington State Department of Transportation, supplementary information

METHODS

The image data were input into an image processing program in order to classify the imagery into impervious pixels versus non impervious pixels. The GIS programs ArcGIS and GRASS were used to complete these analyses. In several other studies, GRASS had been shown to be adequate for the production of impervious surface data from National Agriculture Imagery Program 1-meter data. However, those studies had been based on much smaller land areas. This may have been the first time that such an attempt had been made to classify such a large land area.

Workflow

Clip the imagery (MrSID file type) to the summer chum ESU. Do this for all 4 image files (one for each county in the summer chum ESU). Use ArcGIS to then convert the files to ESRI ASCII grids. Transfer to a computer running Ubuntu (Linux), GRASS software, and import the ESRI ASCII grids into GRASS raster file format for each band. Use i.group and i.target to group the bands.

In ArcGIS, create training files for each county by manually digitizing roofs, roads, and other visible impervious surfaces into a polygon shapefile. After much experimentation it was determined that fewer training polygons gave better results. Therefore, the number of training areas were kept to less than 20 for each county, total. This total includes training polygons for areas that aren't impervious surface. Therefore, the final training dataset includes polygons that are both impervious surface (ID=1) and non impervious surface (ID=2). Training files were transferred to Ubuntu also, using v.in.ogr and v.to.rast.

When both the raster imagery and training data were in GRASS, the image processing then took place. First, a supervised classification method was conducted (i.e., using training data to tell the computer what is and what is not impervious surface). These steps were used to do this:

i.gensig – makes a signature file with the training data
i.maxlik – uses the signature file to determine whether or not each cell of the imagery is or is not impervious
r.neighbors – gets rid of singular pixels of impervious surface (when a single pixel of impervious surface exists without neighboring impervious pixels, at this scale, it is likely just "noise")

Second, an unsupervised classification was conducted (i.e., the computer looks at the imagery and splits it into likely categories). An iterative unsupervised classification was deemed most useful. That is, the image was first split into 20 categories, then those 20 were examined by eye to determine which of them most likely included impervious surfaces. Then of the 4 left those were split into 20 more categories, which themselves were examined. At the end of this process only a few categories were left that adequately represented impervious surfaces. These steps were used:

i.cluster – makes a signature file by looking at the imagery
i.maxlik – uses the signature file to determine whether or not each cell of the imagery is or is not impervious
r.neighbors – gets rid of singular pixels of impervious surface (when a single pixel of impervious surface exists without neighboring impervious pixels, at this scale, it is likely just "noise")

Both the supervised and unsupervised classification methods produced similar results.

After the classification files were created in GRASS they were transferred back to ArcGIS for viewing. This was accomplished by exporting the GRASS files into ESRI ASCII grids, transferring to a Windows computer running ArcGIS, adding a .txt extension to the file in Windows Explorer, and then converting the file from ASCII to Raster using ArcToolbox.

RESULTS AND ADDITIONAL PROCESSING

Overlaying the results onto the imagery in ArcGIS showed that the resulting polygons were not at a level of accuracy that was needed. For one, a significant amount of clusters of "impervious surface" were showing up in the Olympic Mountains region of the study area where the only known impervious surface is logging and access roads. Also, it appeared that impervious surface along roads was underrepresented. This was due to the fact that in many areas roads are not visible in the imagery as they run underneath tree canopy. The imagery, not having infrared bands, does not pick up on that. However, where the road is visible in the imagery, the impervious surface classification was more accurate than the 2003 5-meter classification.

The raster files were converted to polygon shapefiles for ease of editing in ArcGIS. The mountain clusters were deleted and roads were digitized where possible. When needed, additional rooftops were also digitized as many of the red roofs (not common) were not included in the original classification. This process was time consuming as every inch of the imagery was combed over in an iterative and controlled process in order to substantially and comprehensively improve the accuracy. This additional heads-up digitizing was not anticipated but was deemed necessary in order to improve the accuracy of the dataset. The image classification did eliminate the need to digitize everything off the photos so it was helpful in that sense, but it was not accurate enough to use without additional processing. It is likely that smaller geographic areas produce more accurate image processing.

The final impervious surface polygon data represent surfaces such as rooftops, driveways, paved and dirt roads, and quarry sites. They do not include recent clearcuts or other bare ground surfaces. The graphic below shows the impervious surfaces outlined in yellow on top of the imagery.

ERROR ANALYSES

Although every effort was made to view all portions of the imagery and classified data in a systematic fashion over the entire ESU, it was entirely possible that some representations were missed. Assessing the accuracy in a formalized way, then, was needed in order to determine whether or not these data could be input into any subsequent buildout analyses.

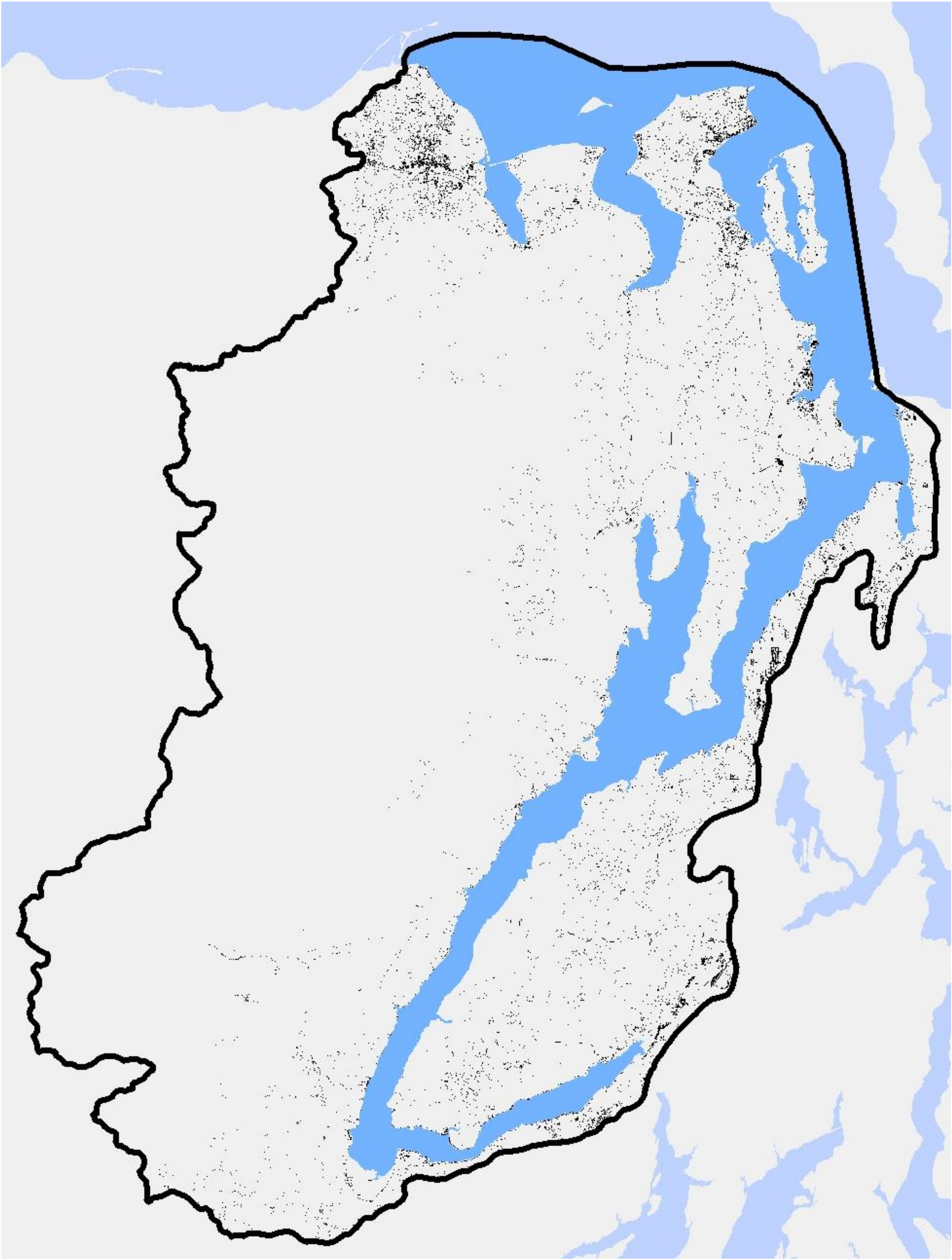
A random point generator in ArcGIS was used to produce a set of 200 random points within the summer chum ESU. Of these, only 161 were on-land points, the rest of the points fell within the Hood Canal water region and were deleted. All 161 points were examined by eye with the aerial imagery underneath to assess whether or not they were accurately portrayed in the impervious data. Accurate points numbered 159, giving a 98.7% accuracy result. However, only one of the random points was actually inside a designated impervious polygon (accurately). Two points were determined to be on impervious surfaces but not designated as such in the impervious data (errors of omission).

A second error estimate was obtained by choosing 97 random points within the impervious data. These points were obtained by:

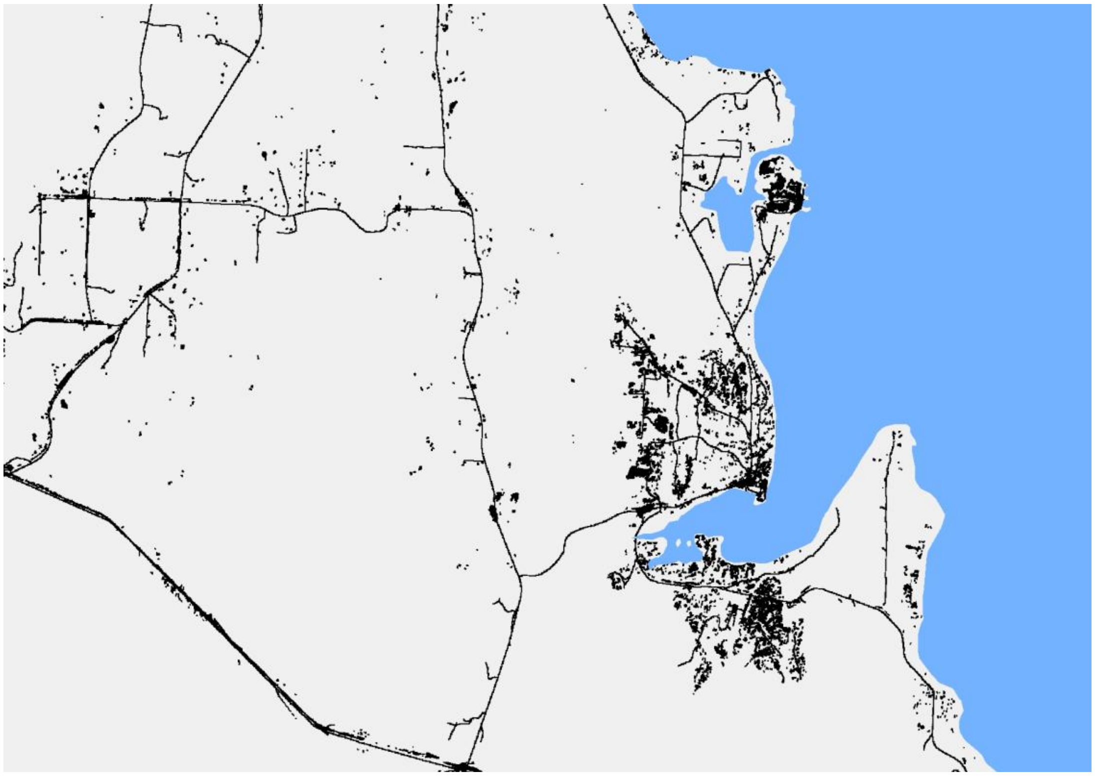
1) Creating an area field in the impervious data table, in feet
2) Dividing the area field by 10
3) Using the ArcGIS random point routine on the impervious polygons with the area field as the number of points per polygon
4) Examining the resulting table to determine how many points total there were (x)
5) Using a random number generator to generate 100 random numbers from 0 to x
6) Selecting featured IDs of those random numbers
7) Creating a new dataset with just those 100 selected points

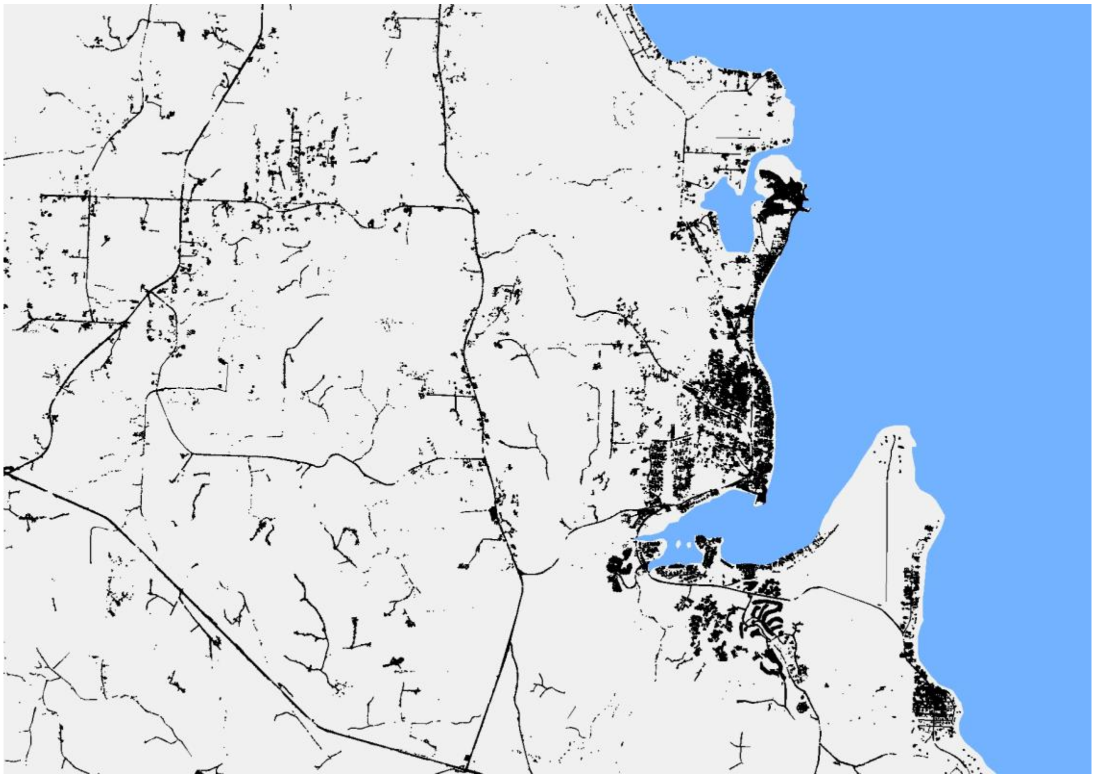
Of the 97 resulting points, three were of uncertain imperviousness and eight were errors of commission (designated impervious when they were actually not). If we include the three uncertain, that makes 11 errors out of 97, for an accuracy of 89%.

The map on the next page shows the impervious surface results over the entire ESU.



A close-up comparison of the 5-meter impervious surface data (used in the last three buildout studies) with the new 1-meter impervious surface data in the Port Ludlow area is shown on the next page.


2003 5-meter impervius data


2006 1-meter impervious data

The data were summarized by basin in order to compare basins with one another. The following table shows each basin (excluding shoreline basins in Kitsap County) and its impervious surface percentage based on the area of the basin.

Basin	Watershed	Percent Impervious
150349	West Kitsap	1%
150362	West Kitsap	2%
150371	West Kitsap	6%
150372	West Kitsap	9%
150373	West Kitsap	8%
150374	West Kitsap	14%
150375	West Kitsap	19%
ANDREWS CREEK	Eastern Strait of Juan de Fuca	1%
BEAR CREEK	Eastern Strait of Juan de Fuca	4%
BIG CREEK	Lilliwaup	0%
BIG QUILCENE RIVER LOWER	Quilcene	4%
BIG QUILCENE RIVER MIDDLE	Quilcene	1%
BIG QUILCENE RIVER UPPER	Quilcene	0%
BOLTON PENINSULA	Quilcene	1%
BROWN CREEK	Lilliwaup	1%
BUNGALOW/SKOOKUM CREEK	Eastern Strait of Juan de Fuca	0%
Bangor Creek	West Kitsap	9%
Big Anderson	West Kitsap	1%
Big Beef (Lower)	West Kitsap	3%
Big Beef (Upper)	West Kitsap	2%
Big Cedar Creek	West Kitsap	0%
Boyce	West Kitsap	1%
CABIN CREEK	Hamma Hamma-Duckabush-Dosewallips	0%
CAMERON CREEK	Eastern Strait of Juan de Fuca	0%
CANYON CREEK	Eastern Strait of Juan de Fuca	0%
CARACO CREEK	Eastern Strait of Juan de Fuca	0%
CASSALERY CREEK	Eastern Strait of Juan de Fuca	11%
CHIMACUM CREEK EAST FORK	Eastern Strait of Juan de Fuca	2%
CHIMACUM CREEK LOWER	Eastern Strait of Juan de Fuca	9%
CHIMACUM CREEK MIDDLE	Eastern Strait of Juan de Fuca	2%
CHIMACUM CREEK UPPER	Eastern Strait of Juan de Fuca	1%
CLIFF/MURHUT CREEK	Hamma Hamma-Duckabush-Dosewallips	0%
Cattail	West Kitsap	4%
Coulter	Union	0%

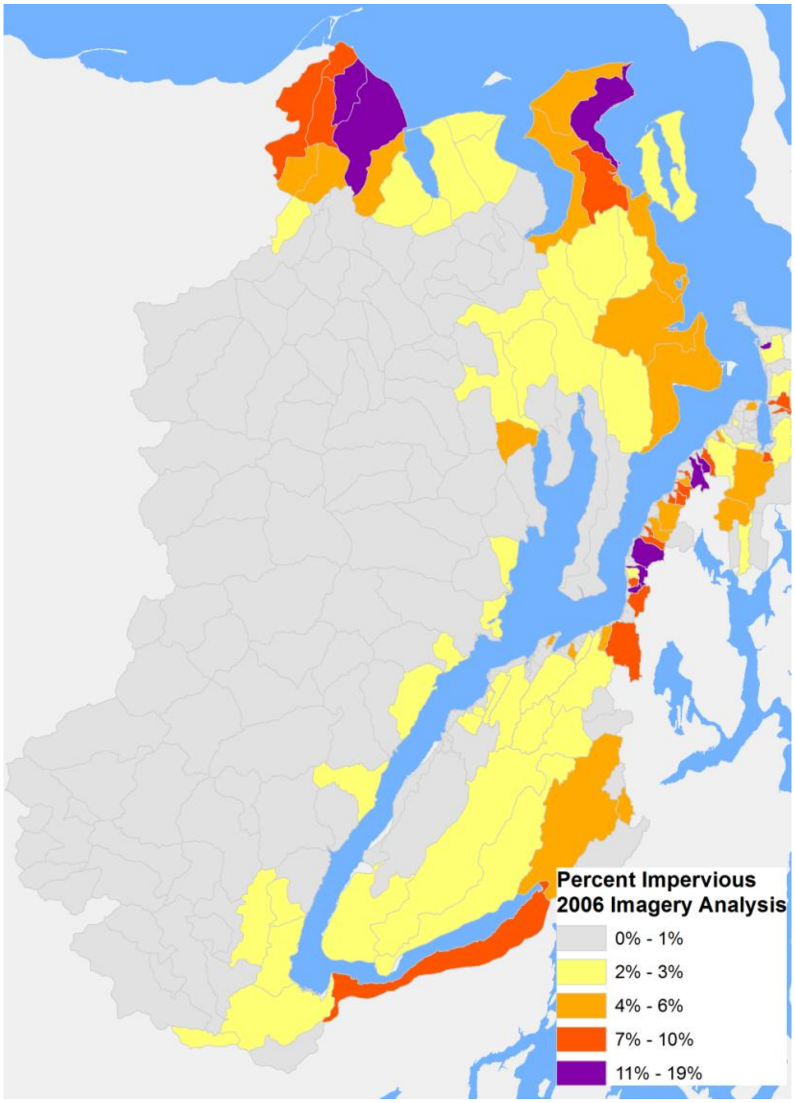
DEVILS LAKE	Quilcene	0%
DISCOVERY BAY EAST SHORE FRONTAL	Eastern Strait of Juan de Fuca	4%
DISCOVERY BAY WEST SHORE LOWER	Eastern Strait of Juan de Fuca	1%
DISCOVERY BAY WEST SHORE UPPER	Eastern Strait of Juan de Fuca	3%
DONOVAN CREEK	Quilcene	1%
DOSEWALLIPS RIVER LOWER	Hamma Hamma-Duckabush-Dosewallips	1%
DOSEWALLIPS RIVER MIDDLE	Hamma Hamma-Duckabush-Dosewallips	0%
DOW CREEK	Lilliwaup	2%
DRY CREEK	Lilliwaup	0%
DUCKABUSH RIVER LOWER	Hamma Hamma-Duckabush-Dosewallips	1%
DUCKABUSH RIVER MIDDLE	Hamma Hamma-Duckabush-Dosewallips	0%
DUNGENESS RIVER BELOW CANYON CREEK	Eastern Strait of Juan de Fuca	4%
DUNGENESS RIVER BELOW GREY WOLF RIVER	Eastern Strait of Juan de Fuca	0%
DUNGENESS RIVER LOWER	Eastern Strait of Juan de Fuca	8%
DUNGENESS RIVER MOUTH	Eastern Strait of Juan de Fuca	7%
Dewatto	West Kitsap	1%
Dogfish (East)	West Kitsap	5%
EAGLE CREEK	Lilliwaup	1%
EDDY CREEK	Eastern Strait of Juan de Fuca	0%
FINCH CREEK	Lilliwaup	1%
FIR CREEK	Lilliwaup	0%
FLAT CREEK	Lilliwaup	0%
FRIGID CREEK	Lilliwaup	0%
FULTON CREEK	Hamma Hamma-Duckabush-Dosewallips	0%
Fern	West Kitsap	0%
GIERIN CREEK	Eastern Strait of Juan de Fuca	13%
GOLD CREEK	Eastern Strait of Juan de Fuca	0%
GREY WOLF RIVER LOWER	Eastern Strait of Juan de Fuca	0%
Gamble	West Kitsap	6%
Gorst (South Headwaters)	Union	3%
Gorst (Upper)	Union	1%
Grovers	West Kitsap	0%
HAMMA HAMMA RIVER LOWER	Hamma Hamma-Duckabush-Dosewallips	0%
HOWE CREEK	Quilcene	0%
Harding	West Kitsap	1%
Hawks Hole	West Kitsap	3%
Hudson	West Kitsap	1%

INDIAN ISLAND	Eastern Strait of Juan de Fuca	3%
JIMMY-COME-LATELY CREEK EAST FORK	Eastern Strait of Juan de Fuca	0%
JIMMY-COME-LATELY CREEK LOWER	Eastern Strait of Juan de Fuca	2%
JIMMY-COME-LATELY CREEK WEST FORK	Eastern Strait of Juan de Fuca	0%
JOHNSON CREEK	Eastern Strait of Juan de Fuca	4%
JORSTED/AYOCK CREEK	Lilliwaup	2%
Johnson (Lone Rock)	West Kitsap	6%
Johnson (Poulsbo)	West Kitsap	1%
Jump Off Joe	West Kitsap	12%
Kinman	West Kitsap	2%
LAKE CUSHMAN FRONTAL	Lilliwaup	1%
LEBAR CREEK	Lilliwaup	0%
LELAND CREEK	Quilcene	1%
LENA CREEK	Hamma Hamma-Duckabush-Dosewallips	0%
LILLIWAUP CREEK	Lilliwaup	0%
LITTLE QUILCENE LOWER	Quilcene	1%
LITTLE QUILCENE UPPER	Quilcene	0%
Laudine DeCouteau	West Kitsap	0%
Lemolo-Klaebel	West Kitsap	0%
Little Anderson	West Kitsap	7%
Little Beef	West Kitsap	2%
Little Boston	West Kitsap	6%
Lost	Union	0%
MARROWSTONE ISLAND	Eastern Strait of Juan de Fuca	3%
MATRIOTTI CREEK	Eastern Strait of Juan de Fuca	6%
MC1	Lilliwaup	1%
MC2	Union	7%
MCDONALD CREEK	Hamma Hamma-Duckabush-Dosewallips	2%
MCTAGGERT CREEK	Lilliwaup	0%
MILLER PENINSULA	Eastern Strait of Juan de Fuca	2%
Martha John Creek	West Kitsap	2%
Middle	West Kitsap	1%
Mission	Union	2%
Nellita	West Kitsap	2%
OAK/MATS MATS BAY	Eastern Strait of Juan de Fuca	4%
PATS CREEK	Eastern Strait of Juan de Fuca	1%
PENNY CREEK	Quilcene	0%
PORT LUDLOW	Quilcene	5%
PORT TOWNSEND BAY	Eastern Strait of Juan de Fuca	13%
POTLATCH CREEK	Lilliwaup	2%
PURDY CREEK	Lilliwaup	1%

QUIMPER PENINSULA	Eastern Strait of Juan de Fuca	5%
ROCKY BROOK	Hamma Hamma-Duckabush-Dosewallips	1%
Rendsland	West Kitsap	2%
SALMON CREEK LOWER	Eastern Strait of Juan de Fuca	1%
SALMON CREEK NORTH	Eastern Strait of Juan de Fuca	0%
SALMON CREEK UPPER	Eastern Strait of Juan de Fuca	0%
SCHAERER CREEK	Hamma Hamma-Duckabush-Dosewallips	1%
SEQUIM BAY EAST SHORE	Eastern Strait of Juan de Fuca	2%
SEQUIM BAY WEST SHORE	Eastern Strait of Juan de Fuca	2%
SKOKOMISH RIVER NORTH FORK HEADWATERS	Lilliwaup	0%
SKOKOMISH RIVER NORTH FORK LOWER	Lilliwaup	0%
SKOKOMISH RIVER SOUTH FORK LOWER	Lilliwaup	0%
SKOKOMISH RIVER VALLEY	Lilliwaup	2%
SLAB CAMP CREEK	Eastern Strait of Juan de Fuca	0%
SLEEPY HOLLOW CREEK	Eastern Strait of Juan de Fuca	0%
SNOW CREEK	Eastern Strait of Juan de Fuca	1%
SPENCER/MARPLE CREEK	Quilcene	0%
SQUAMISH HARBOR	Quilcene	4%
SUND/MILLER CREEK	Lilliwaup	1%
Sam Snyder	West Kitsap	3%
Seabeck	West Kitsap	2%
Shoreline	West Kitsap	0%
SpringA	West Kitsap	3%
Stavis	West Kitsap	2%
TARBOO CREEK	Quilcene	1%
THORNDYKE CREEK	Quilcene	1%
TOANDOS PENINSULA EAST SHORE FRONTAL	Quilcene	1%
TOANDOS PENINSULA WEST SHORE FRONTAL	Quilcene	1%
TOWNSEND CREEK	Quilcene	1%
TRAPPER CREEK	Eastern Strait of Juan de Fuca	0%
TUNNEL CREEK	Quilcene	1%
TUNNEL CREEK NORTH FORK	Quilcene	0%
TUNNEL CREEK SOUTH FORK	Quilcene	0%
TURNER CREEK	Quilcene	2%
Tahuya	Union	2%
Thomas	West Kitsap	0%
Thompson	West Kitsap	0%
Todhunter	West Kitsap	1%
Union	Union	5%

Unnumbered10	West Kitsap	11%
Unnumbered11	West Kitsap	6%
Unnumbered12	West Kitsap	9%
Unnumbered16	West Kitsap	12%
Unnumbered17	West Kitsap	0%
Unnumbered19	West Kitsap	8%
Unnumbered20	West Kitsap	3%
Unnumbered23	West Kitsap	4%
Unnumbered30	West Kitsap	2%
Unnumbered34	West Kitsap	10%
Unnumbered35	West Kitsap	3%
Unnumbered36	West Kitsap	6%
Unnumbered38	West Kitsap	7%
Unnumbered43	West Kitsap	7%
Unnumbered49	West Kitsap	0%
Unnumbered51	West Kitsap	5%
Unnumbered52	West Kitsap	7%
Unnumbered53	West Kitsap	17%
Unnumbered55	West Kitsap	5%
Unnumbered6	West Kitsap	1%
Unnumbered64	West Kitsap	1%
Unnumbered68	West Kitsap	0%
Unnumbered71	West Kitsap	0%
Unnumbered75	West Kitsap	6%
Unnumbered76	West Kitsap	0%
Unnumbered78	West Kitsap	0%
VANCE CREEK	Lilliwaup	1%
WAKETICKEH/CUMMINGS CREEK	Hamma Hamma-Duckabush-Dosewallips	0%
WALKERS CREEK	Hamma Hamma-Duckabush-Dosewallips	2%
Wildcat	Union	1%

These results can also be shown geographically as shown in the map on the next page.



CONCLUSIONS

Given this lower level of accuracy as well as the known omission of many stretches of roads, it is desirable to obtain a more accurate dataset by merging it with an existing road dataset or by using a dedicated image processing program. However, it is unknown how an image processing program would improve (if at all) the results given that the input imagery does not contain any infrared bands.

Even so, the accuracy of 89% is not bad for such an exercise and is good enough for use in the next buildout study. The benefit to using it is that it has a much higher resolution than the impervious data used previously, and this should give more accurate measures of average impervious percentages within land use groups at a parcel scale.

See also GI Statistic in the Permitting section for an analysis of hotspots in the impervious data*

Buildout Studies

Buildout studies were conducted for the years 2003, 2006, and 2008 in order to determine how much impervious surface could be expected on a parcel by parcel basis in the future, given the current regulatory environment. The current regulatory environment is mostly framed by the zoning regulations set forth in maps and county codes for each county. However, there are other regulations that sometimes affect the ability to build on any given parcels. These other regulations were included in these buildout studies as well, where feasible, but it is likely that local ordinances were not included and could be added when more accuracy is needed in a particular location.

Though many typical buildout studies are based on projecting future population trends in given years or projecting future housing additions, this study focused on projecting future impervious surface additions as allowed under zoning laws. Therefore these studies do not have an end-date for buildout. The end-date, then, is however long it takes to get to full buildout under current zoning laws. The focus on impervious surfaces was developed so as to be more pertinent to salmonid habitat quality measurements.

Methods for the studies are found in the report titled, "Estimating Impervious Surface in the Summer Chum ESU under Buildout Conditions." Results for the 2003 study are also found there. **Results, using the same methods, for the 2008 update are reported on here.**

DATA INPUTS

Mason County parcels: received 6/15/2008
Mason County zoning: no updated to zoning were identified, the "development areas" shapefile used is dated 2006
Jefferson County parcels: received 6/11/2008
Jefferson County zoning: dated 8/16/2008
Port Townsend zoning: dated 8/16/2008
Kitsap County parcels: downloaded 6/10/2008
Kitsap County zoning: downloaded 6/10/2008
Allyn zoning:
Belfair zoning: online map dated 5/22/2008

METHODS

Methods for the 2008 buildout were the same as reported in the report mentioned above except where noted here.

In the 2003 and 2006 buildout studies the R10 zone in Belfair was assigned rural residential landcodes. This was an error as R10 does not signify 1 dwelling per 10 acres, rather, it signifies 10 dwellings per 1 acre. The landcodes for these zones ought to have been assigned to "apartments." This correction is reflected in the 2008 version. Also in Mason County, the parcels with a landuse of "open sp (cu)" (open space) were assigned their current landcodes in buildout as it was unknown what these parcels were. It was assumed that they were reserved properties, perhaps with easements.

In Kitsap County the parcel data include a field called num_dwell (number of dwellings). The data in that field was used in the 2008 analysis where it hadn't been used in the previous buildout studies. In some cases this changed the current and buildout landcodes that parcels were assigned to.

In some cases the current and buildout landcodes for parcels changed between the 2008 and previous buildout studies solely due to rounding issues. The table by which residential landcodes were assigned is shown below:

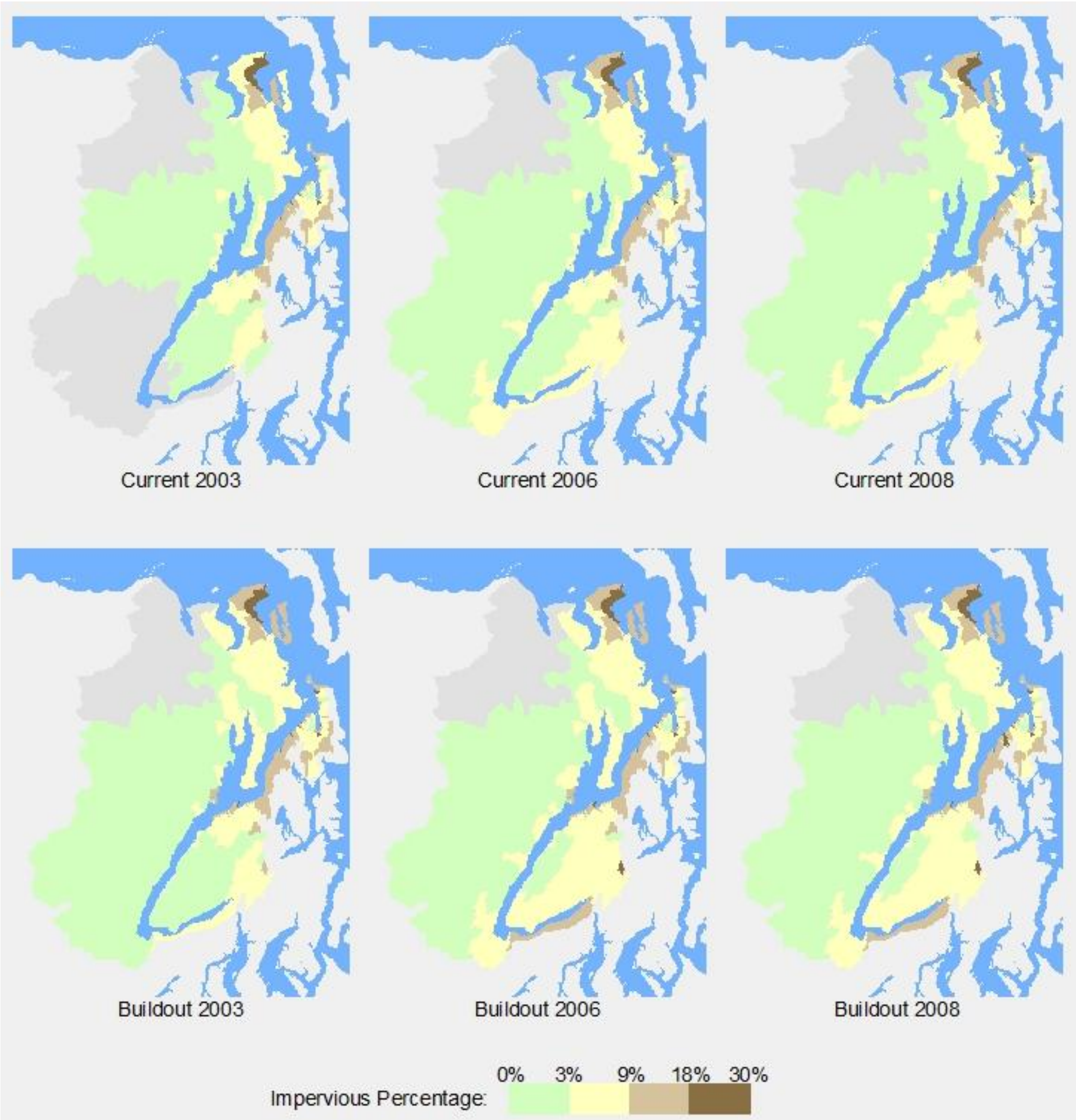
Landcode	Density
Open Land	<= 1 HU[1] per 10 acres
Rural	Between 1 HU per 10 acres and 1 HU per 5.2 acres
Estate	Between 1 HU per 5.2 acres and 1 HU per 2.6 acres
Suburban	Between 1 HU per 2.6 acres and 1 HU per 1 acre
Urban Low	Between 1 HU per 1 acre and 12,480 sq ft
Urban Standard	Between 1 HU per 12,480 sq ft and 6,150 sq ft
Urban Medium	Between 1 HU per 6,150 sq ft and 3,114 sq ft
Urban High	>= 1 HU per 3,114 sq ft

In the 2008 study, the size of the parcel was calculated in square feet instead of acres for a more precise measure of the property size. When a parcel has 1 housing unit in 5.249 acres, for example, it was previously assigned to the Estate landcode whereas in the 2008 buildout it was more properly assigned to the Rural landcode.

In Jefferson County, there were 10 parcels in the IF_1:20 zone. In the previous buildout studies these parcels were assigned to a current landcode of vacant and a buildout landcode of wooded. However, in re-examining the code, it was determined that a dwelling unit could be built on these properties. The 2008 study reflects this by assigning these parcels a buildout landcode of open land. This increases the buildout impervious for these parcels from .83% (wooded) to 4% (open land).

RESULTS

Results were tallied by basin to get a general overview of the data and trends. These are shown below.



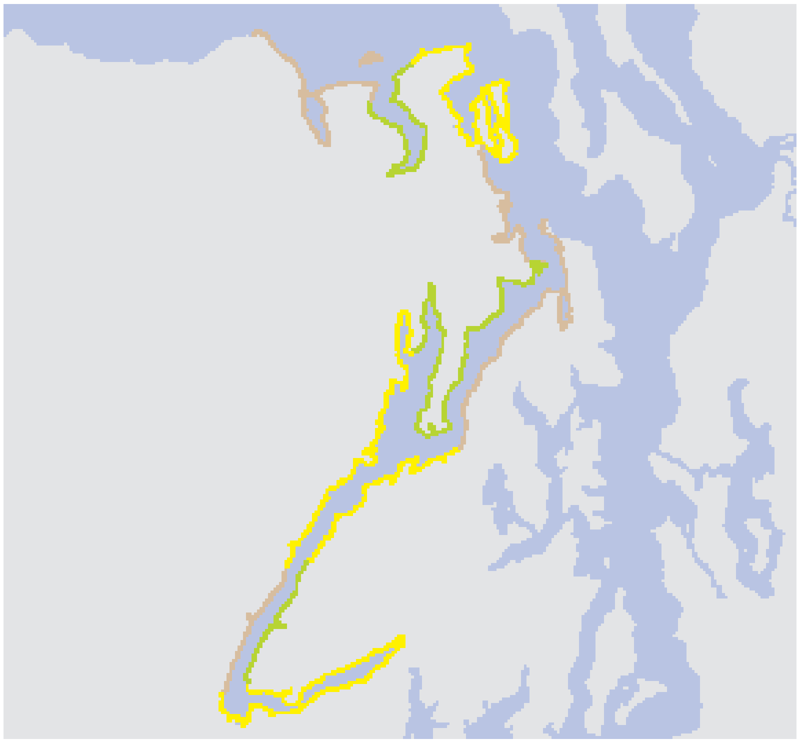
The riparian corridor statistics were also calculated and put into a table along with all of the riparian corridor statistics from the 2006 buildout study. These results are shown in the table below. There was a slight change in methodology between the 2003 estuarine analysis and the subsequent analyses so the 2003 results are not shown.

	current		**buildout**	
Name	2006	2008	2006	2008
Big Anderson Creek	12%	12%	15%	15%
Big Beef Creek	12%	12%	13%	12%
Big Quilcene River	7%	8%	9%	11%
Chimacum Creek	5%	5%	6%	6%
Dewatto River	5%	4%	5%	5%
Dosewallips River	9%	10%	11%	12%
Duckabush River	7%	7%	11%	12%
Eagle Creek	12%	11%	12%	11%
Finch Creek	15%	16%	15%	16%
Fulton Creek	10%	13%	16%	20%
Hama Hama River	5%	3%	5%	3%
Lilliwaup Creek	12%	12%	14%	14%
Little Anderson Creek	8%	8%	8%	9%
Salmon/Snow Creeks	8%	8%	12%	12%
Skokomish River	3%	2%	3%	3%
Tahuya River	4%	4%	4%	4%
Union River	5%	4%	6%	5%

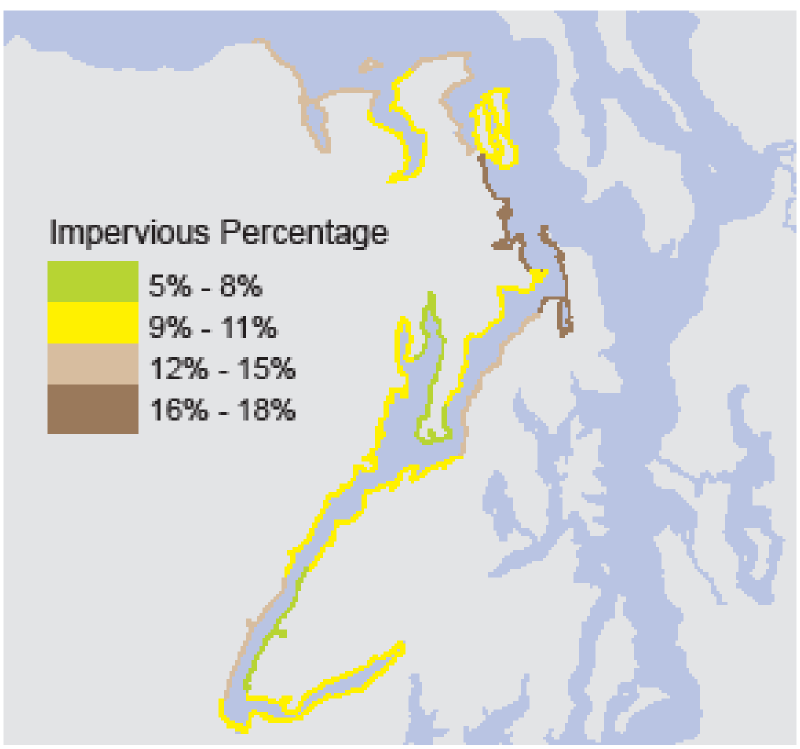
The results of the buildout studies for the riparian corridors are shown in the table below. The 2003 buildout study did not have comparable numbers for Mason County due to parcel data not being available at that time for that area. Those are left blank in the table. The Little Quilcene, Big Quilcene, Chimacum, Duckabush, Dosewallips, Lilliwaup, Miller, and Snow riparian corridors all show multi-percentage point increases in impervious surface under full buildout conditions.

	current			buildout		
Name	**2003**	**2006**	**2008**	**2003**	**2006**	**2008**
Anderson Creek	1.90%	1.90%	1.79%	2.16%	2.11%	2.00%
Big Beef Creek	6.33%	6.65%	6.64%	7.52%	7.69%	8.00%
Big Quilcene River	4.15%	8.52%	8.57%	6.95%	11.22%	11.39%
Chimacum Creek	6.59%	9.33%	9.48%	12.55%	14.16%	12.09%
Dewatto River		1.52%	1.35%		1.81%	1.66%
Dosewallips River	4.89%	5.27%	5.19%	7.04%	7.81%	7.88%
Duckabush River	5.75%	6.23%	6.30%	9.58%	10.12%	10.11%
Eagle Creek		10.36%	10.33%		11.57%	11.56%
Finch Creek		13.13%	13.20%		15.30%	15.30%
Fulton Creek	6.03%	6.36%	6.39%	5.02%	5.35%	5.29%
Hamma Hamma River/John Creek		1.23%	0.95%		1.94%	1.76%
Jorsted Creek		10.19%	9.29%		11.36%	10.29%
Lilliwaup Creek		4.35%	4.29%		7.22%	7.59%
Little Anderson	7.77%	7.78%	8.81%	8.69%	8.61%	9.87%
Little Quicene River	8.69%	8.67%	8.74%	11.62%	12.55%	12.66%
Miller Creek		12.59%	12.52%		17.08%	17.00%
Salmon Creek	3.49%	3.70%	3.61%	3.63%	3.88%	3.97%
Skokomish River		3.32%	3.05%		4.12%	3.91%
Snow Creek	7.74%	7.95%	8.08%	10.21%	10.61%	10.66%
Tahuya River		3.84%	3.87%		5.68%	5.72%
Union River		6.63%	6.57%		8.09%	8.11%

The nearshore unit results were calculated for 2008 and are shown below.



current 2008



buildout 2008

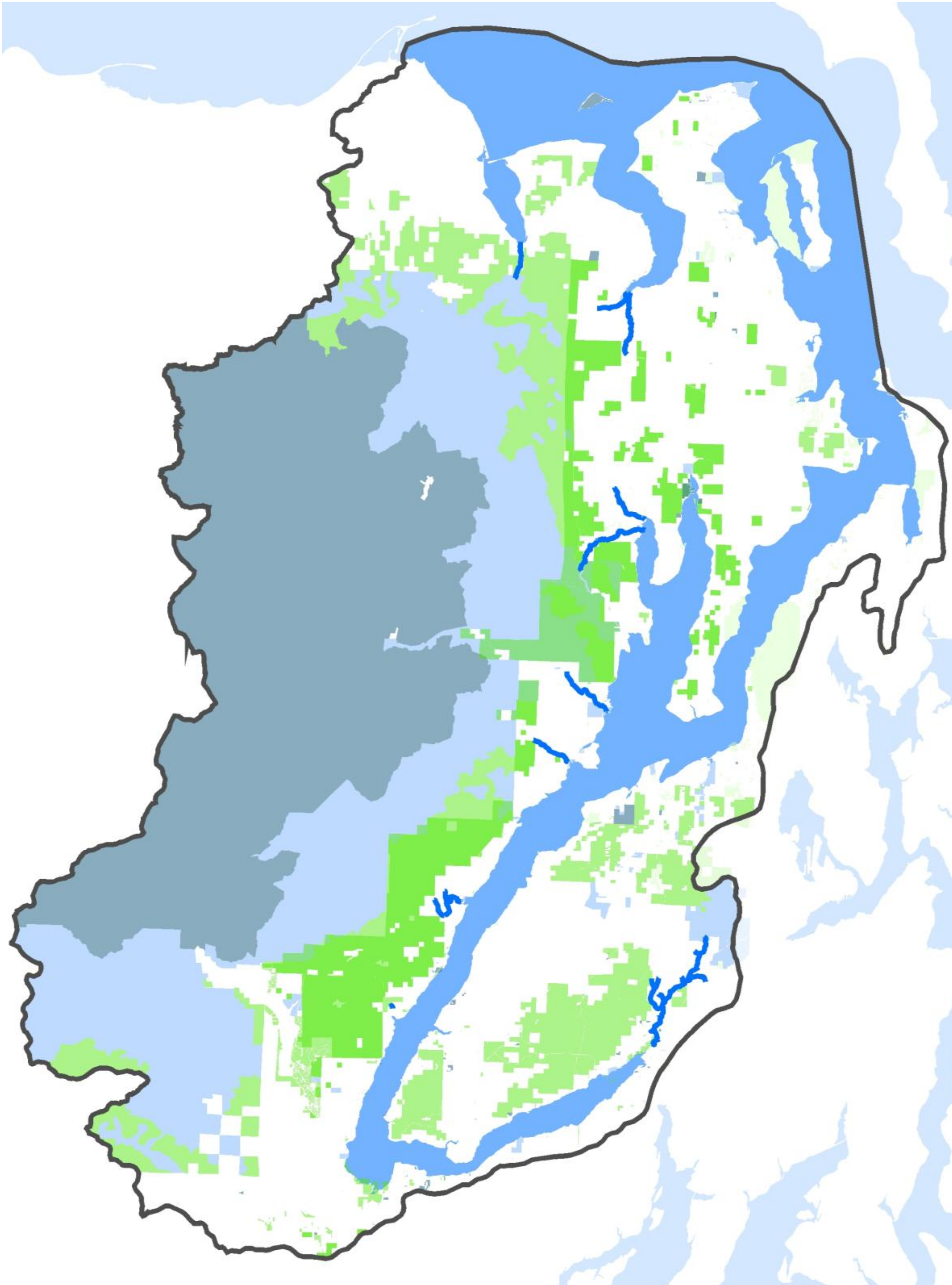
Please note that full buildout conditions in terms of impervious surfaces are based on current building practices. Therefore, if low impact development practices become the norm in the future, it is likely that the amount of impervious surface associated with the same development could be less than predicted in this analysis.

Data Overlays

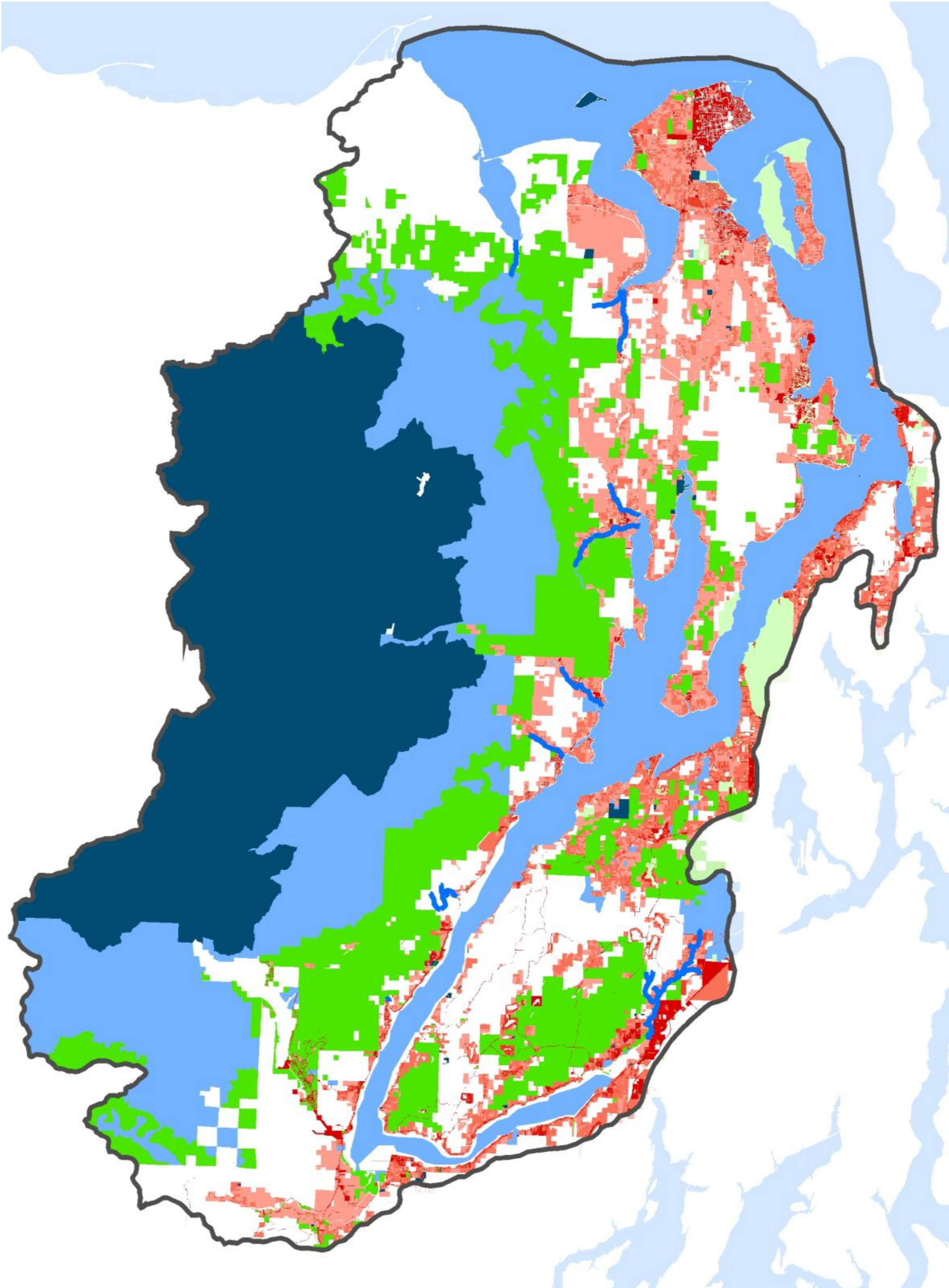
There are many ways in which these analyses can be put together to illustrate impacts to summer chum habitat (and other terrestrial and aquatic species) on an ESU-wide scale, a basin scale, or a parcel scale. They can also be combined with other data such as those developed under the following programs: Hood Canal Dissolved Oxygen Project, the Puget Sound Nearshore Ecosystem Restoration Program, and the HCCC's Riparian Assessment.

One example of a data overlay process is presented on the following pages.

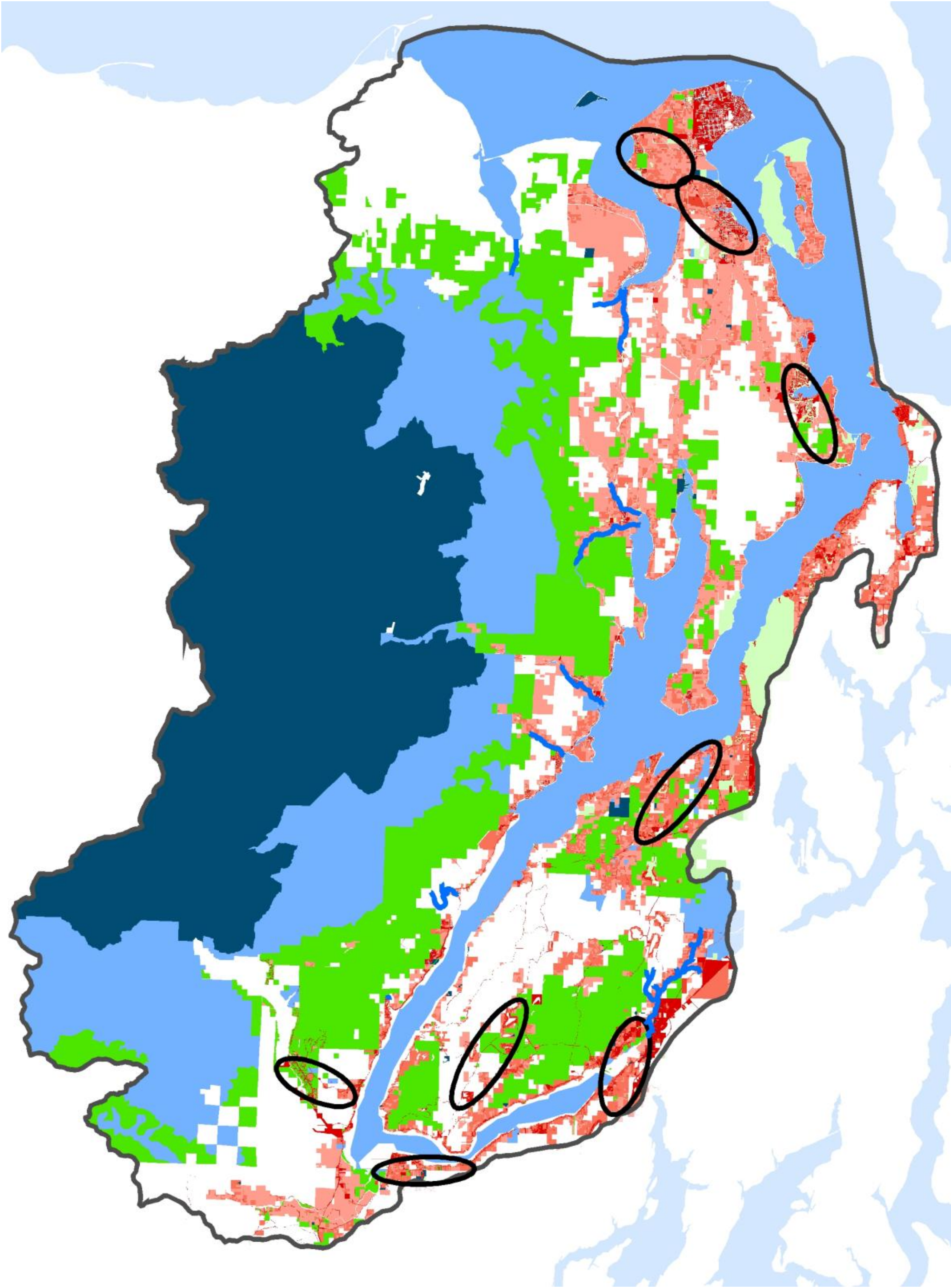
The eight summer chum target streams are shown here, in dark blue.



The protected areas database is shown here, with dark blue denoting a conservancy rating of 4 while light green denotes a conservancy rating of 1.



The protected areas are placed together with the buildout data on this map. The buildout data is shown in red with the dark red denoting a high level of potential buildout and white denoting no potential buildout.



The permit hotspots are shown along with the other data, here. This shows that the places that could potentially become highly built-out are also the areas that are seeing permitting hotspots.

Workshops

Several workshops have been held and presentations given to provide access to these studies and there results to other scientists. They are listed below:

Georgia Basin Puget Sound Ecosystem Conference: Formal presentations were given during this conference in March 2005 and March 2007. An informal presentation was given during the February 2009 conference.

Land Use Permit Tracking Workshop: This workshop was presented to approximately 20 biologists in May 2007. It involved the presentation of the permit work, the buildout work, and the forest practices work and followed with suggestions from the group on how to improve the studies.

The HCCC GIS: Geospatial Tools for Salmon Recovery and Environmental Assessment: This workshop had an attendance of approximately 50 including biologists, planners, and GIS personnel and was held in February 2009.

Material from the HCCC GIS workshop held in February 2009 is provided on the following pages including the agenda and associated handouts. The GIS portion of the talk relied mainly on interactive GIS illustrations so slides were not a major portion of the workshop.

The Hood Canal Coordinating Council GIS: Geospatial Tools for Salmon Recovery and Environmental Assessment

Silverdale Community Center Evergreen Room 9729 Silverdale WAY NW, Silverdale, WA 98370

AGENDA

1:00 to 1:20 PM

Scott Brewer, Executive Director of the Hood Canal Coordinating Council, will present an overview of how GIS tools can play a valuable role in salmon recovery planning, implementation, and monitoring.

The Hood Canal GIS in the Context of other Puget Sound Initiatives *1:20 to 1:40 PM*

Eric Edlund, GIS Analyst for Stillwater Sciences, will talk about the integration of GIS efforts with other Puget Sound planning efforts. Eric's talk will focus on how:

- The **Hood Canal Dissolved Oxygen Project** uses GIS for measuring the spatial and temporal variability of threats within Hood Canal
- The **Puget Sound Nearshore Ecosystem Restoration Program** relies on GIS to identify historic changes and establish priorities
- Other groups make GIS a dynamic tool in general **habitat protection and restoration efforts**

The Hood Canal Coordinating Council GIS Project *1:40 to 2:25 PM*

Gretchen Peterson, PetersonGIS, will present how HCCC has been integrating GIS analysis in its Summer Chum recovery planning efforts since 2003. Gretchen's presentation will cover:

- The methodology and conclusions of a Hood Canal **Build Out Study** based the current comprehensive land use plans of Jefferson, Kitsap, Clallam and Mason Counties
- Highlights of the **Impervious Surfaces Study**, including discussion on methods for using new data that is available and how its application can reveal different results
- An overview of the methodology and results of the **Land Use Permit Tracking Study** in Jefferson, Kitsap, and Mason Counties

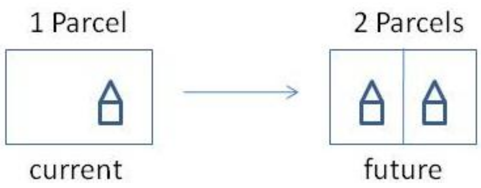
• Using GIS to track **Forest Practices Applications** and **Protected Lands** within Hood Canal, the data lineage for establishing these programs, and the use of animation for showing results How to layer data to create a **Basin-Level Zoom-In** to gain a better understanding of on-the-ground events in a local watershed Break for Refreshments *2:25 to 2:35 PM* **Determining Next Steps for the HCCC GIS Project** *2:35 to 4:00 PM*

How can HCCC refine and expand the GIS program to improve its application to salmon recovery? Workshop participants will play an important role in **determining the future directions of the HCCC GIS Project**. John Kliem, Creative Community Solutions, will lead workshop participants through a facilitated discussion of identifying what should be the next steps for the HCCC GIS Project.

Participants will also get the opportunity to indicate their interest in becoming involved in future efforts.

Question

How much impervious surface can be expected on each parcel in the future, given the current regulatory environment?



Data Inputs

impervious surfaces: based on 2003, 5 meter resolution impervious surface data; newer impervious surface data at a better resolution are now available and may be used in the model for the next iteration

parcels: parcels from all four counties were obtained including current landuse for each parcel as assigned by tax assessors

zoning: zoning layers for all four counties and Port Townsend were obtained

In some cases, certain supporting layers such as **critical areas, aquifer recharge areas, and sewers** were also used.

Method (simplified)

Combine landuses into 40 umbrella categories of assumed similar imperviousness. Calculate average % impervious for each category via overlay of impervious data with parcel landuse groups. Determine each parcel's future landuse category via overlay with zoning and other layers. Use average percent impervious calculated from current data to assign a future percent impervious to projected landuse category.*

* Dave Nash, Kitsap County GIS Analyst, developed many of the methods in this study

Iterations

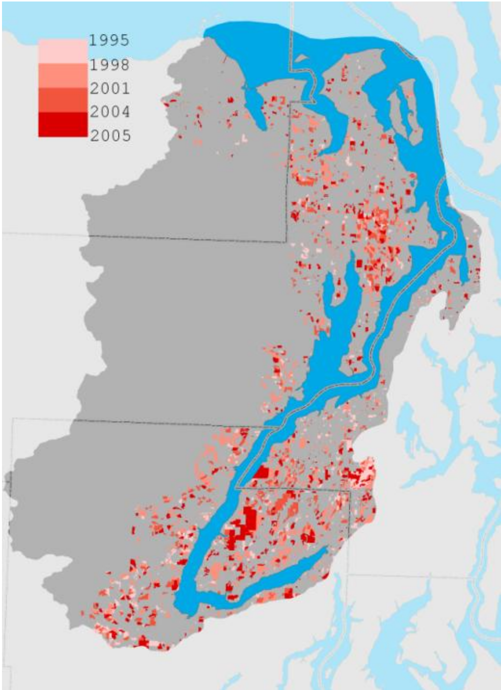
1) 2003 parcel and zoning data with impervious data from 2003
2) 2006 parcel and zoning data with impervious data from 2003
3) 2008 parcel and zoning data with impervious data from 2003
4) 2009 parcel and zoning data with impervious data from 2006 (not completed)

Question
Where have forest harvests occurred within the last ten years?

Data Inputs
FPA: Washington State Department of Natural Resources Forest Practice Application Permit Database; all permit types including type IV for 1995 - 2006; permits were used as a proxy for actual forest harvest
ONF: Olympic National Forest harvest database; data for 1995 – 2006, very few harvest activities for those years were identified

Method (simplified)
Process the FPA data with a custom program built by PetersonGIS to create topologically discrete polygons since the original data contain an extensive amount of overlapping harvest applications. Polygons are then assigned an assumed harvest year based on the effective date or renewal date, whichever is later. Applications not flagged as "cutting" or "removing" timber are removed from the data.

Since the FPA data are only a proxy for harvest, with no guarantee that the permitted harvest actually occurred, an error analysis using aerial photography was conducted.



Results
Total permitted harvest for years 1995-2006 accounted for 21% of the summer chum watershed. Permits by year are shown at right.

Error Estimates
Of 50 randomly chosen permits, 78% were actually harvested, as determined via overlay with year 2006 and year 2000 imagery. When comparing acreage cut within these (as some were only partially cut) the error is higher: 70%. Some discrepancies in the data include: harvests that occurred much later than permitted, harvests not flagged as conversions that were actually converted, areas that were thinned as opposed to completely cut, and permitted cuts that were only partially cut. A more robust way to track harvests would be to digitize recent, high-resolution, aerial photography.

Question

Where are the impervious surfaces in the Hood Canal?

Data Inputs

imagery: imagery is from the National Agriculture Imagery Program, 1 meter resolution, color, year 2006, summer chum ESU

roads: supplementary information

Method (simplified)

Use image processing algorithms to run a supervised classification of the imagery. Manually improve results with visual comparisons between results and imagery. Run error statistics to determine difference between ground-truthed and modeled data.

Fine print: both supervised and unsupervised classification methods were tested. Both gave similar results. *Generate signature* for supervised methods and *cluster* for unsupervised methods were used. *Maximum likelihood* algorithm was used for the final classification and the *neighbors* algorithm was used for initial clean-up.

Results

Polygons representing impervious surfaces such as rooftops, driveways, paved and dirt roads, and quarry sites were extracted. They do not include recent clearcuts or other bare ground surfaces. The data represent polygons identified as being completely impervious. See graphic, below.

Error Estimates

Overall: 98.7% concurrence using 161 random points throughout study area

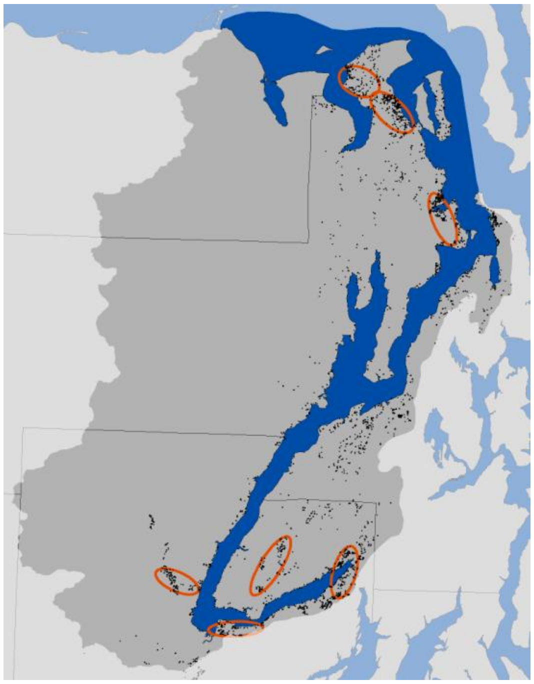
Errors of commission: 89% concurrence using 97 points randomly chosen from the classified pixels

Questions
Where and when are building permits being issued? How much impervious surface is tied to each permit? Are there any spatial patterns present?

Data Inputs
Jefferson County: Spreadsheets of building permits and shoreline development permits for years 2003, 2004, and 2005; received from the Jefferson County Department of Community Development
Kitsap County: Shapefiles for years 2003, 2004, and 2005 of mobile home lots, mobile home parks, residential bulkheads, and other permit types received from the Kitsap County Department of Community Development
Mason County: Spreadsheets for years 2003, 2004, and 2005 of commercial, shoreline, building, and other permit types received from the Mason County Department of Community Development
All data, except mobile home permits in some cases, included square footage of first-floor impervious surface, permit-issue date, and location of permit via parcel number and address.

Method (simplified)
Convert data from spreadsheet format to GIS format. Clean data, then group by basin and conservation unit. Basin totals, median impervious surface expansion, and other metrics to be calculated. Use spatial statistics to find patterns in the data.

Results
Some patterns were discernable in terms of spatial distribution of permits. The pattern algorithm used was nearest neighbor hierarchical clustering, 90% confidence interval, 2nd order. These results are shown as red circles, at right.



Correlations with other variables, such as schools, were not strong.

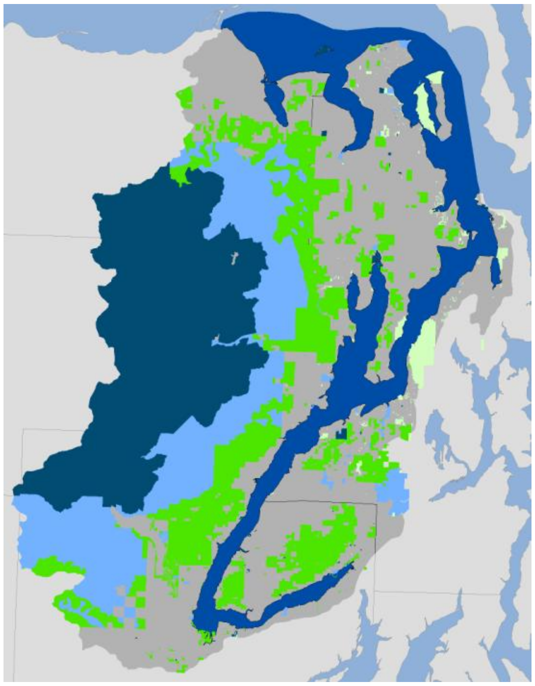
Question
Where are the protected areas and what level of protection do they have?

Data Inputs
Mason County parcels: dated 2.13.2007; landuse codes, owner names, and description fields
Jefferson County parcels: dated 11.7.2007; landuse codes, owner names (with special permission – not to be distributed)
Kitsap County parcels: dated 3.3.2008; with "land" table including landuse codes, and owner name
Public Land Database: 8.24.2006; data from CommEnSpace
Olympic National Forest: forest boundaries and administration types

Method (simplified)
Use search and select combinations within the parcel data to identify parcels that have some protection value. Assign protection levels according to the Public Land Database protocol (U.S. National Gap Analysis Program adjusted for Vermont). Also use Public Land Database as ancillary data to ensure that all parcels are accounted for.

Assign protection levels to the Olympic National Forest data using the same protocol. Combine both datasets into one geodatabase.

Results
Shown at right



Habitat Assessment

The habitat assessment project was designed as a means of gathering habitat conditions data into one database from disparate sources. The habitat conditions database contains 22 related tables in an MS Access database format. The database is designed to incorporate in-stream data measurements (such as pool function, number of logs, or percent canopy) from a variety of measurement methods and sources. It is fully expandable to handle any kind of in-stream measurement taken and to include any kind of location information. In this way, data from all types of protocols for stream monitoring, including those that have not yet been developed can be uploaded into the database. To accomplish this, new location parameters and measurement parameters may need to be added to the appropriate tables (LocationParameters and Parameters, respectively). Currently, data from the Point No Point Treaty Council (PNPT), Hood Canal Salmon Enhancement Group (HCSEG), and Northwest Indian Fisheries Commission (NWIFC) are included.

The principle data organization method of the database is to store all of the measurements in one table – HabitatConditions – regardless of type, protocol, source, date, and location. Each row in the HabitatConditions table contains one and only one habitat measurement. This is a change from the traditional recording method wherein measurements are typically stored in separate columns and arranged in rows according to location. This traditional method creates data redundancy and consequently updates and changes are difficult, error-ridden, and time-consuming. Additionally, to add new types of measurements to locations in the traditional method, new columns are created, and the potential for tables containing large numbers of columns is great. The habitat conditions database contains just two columns for all in-stream measurements (Measurement and TextMeasurement in the HabitatConditions table). Because the type of measurement, location, and other supporting information for the measurements is found in linked tables, the database is easiest to read in query form. An understanding of the database structure and relationships is needed prior to writing queries.

Database Content Summary

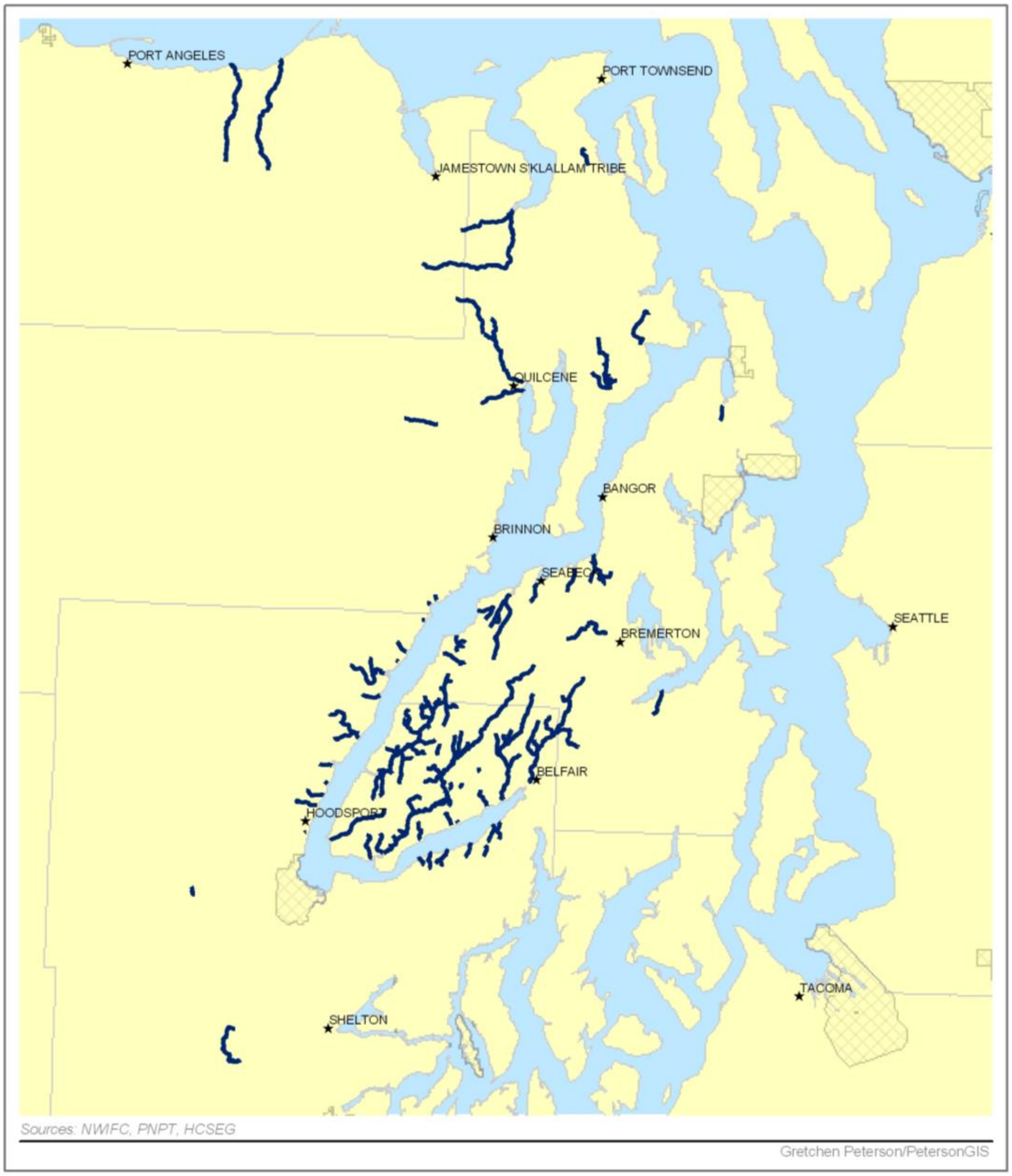
This habitat conditions database contains data on in-stream ecological indicators in the Hood Canal watershed. The data were collected between 1989 and 2003, during every year except 1995 and 2000. Two protocols for data collection were used during this time frame: the TFW Monitoring Program and the Hood Canal Salmon Enhancement Group (HCSEG) StreamTeam Protocol. Records from the Point No Point Treaty Council (PNPT), HCSEG, and the Northwest Indian Fisheries Commission (NWIFC) efforts are included.

In-stream habitat data such as channel width, gradient, and several large woody debris metrics are represented here for a total of 103 measured parameters. The database is designed to accommodate any type of in-stream measurement and is ideal for the management of data from multiple sources. Additionally, it is geographically enabled in that all measurements are tied to a location which contains the stream ID, from-feet, and optionally the to-feet (for linear measurements). This information can then be exported as route-events for use in a GIS with the WA Department of Fish and Wildlife (WDFW) hydrologic dataset. Other types of geographic location technologies may be implemented in the future, such as global positioning system (GPS) data. Location attributes such as GPS can be added to the database by creating a new Location Parameter.

The original data were obtained in modules as follows:

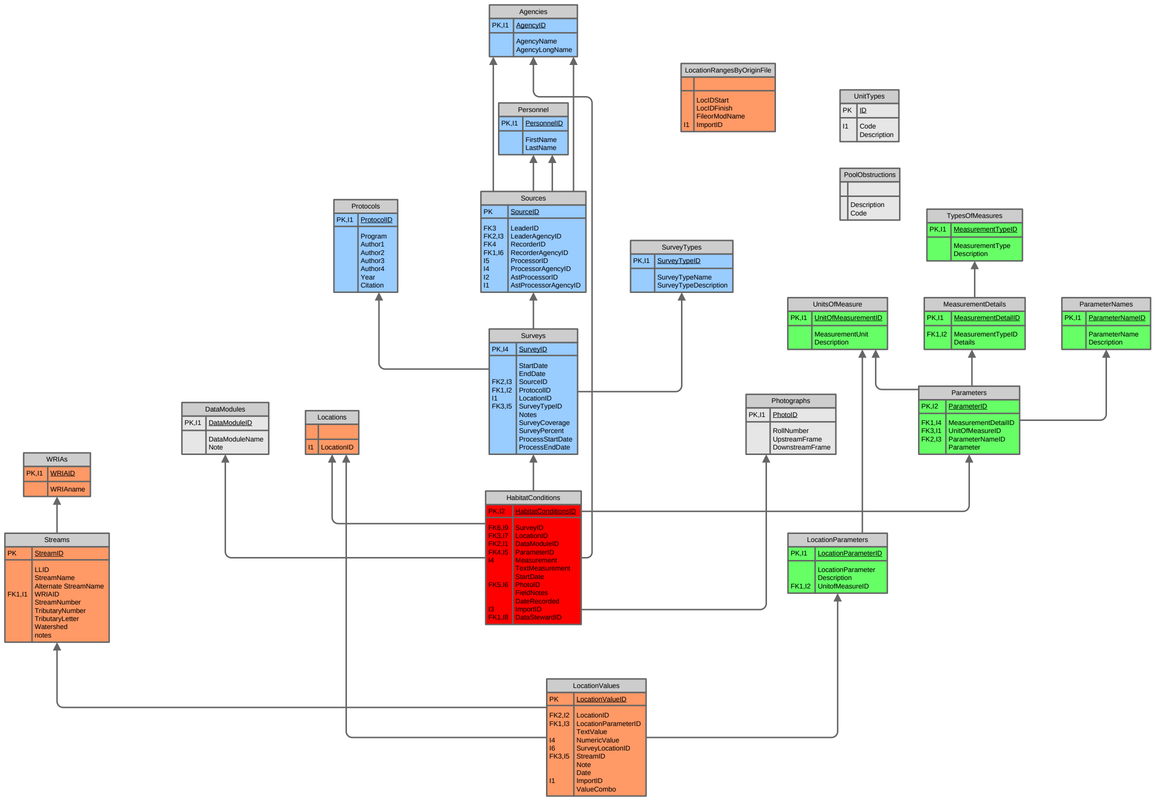
AGENCY	MODULE
HCSEG	Benchmarks
	Channels
	LWD
	LWD Totals
	Pools
NWIFC	Habitat Survey 1989 to 1991
	Habitat Survey post 1991
	LWD Survey
	Reference Point Survey 1989 to 1991
	Reference Point Survey Post 1991
	Sediment Survey
PNPT	Habitat
	Pool
	Riparian Seral Stage
	Woody Debris Jams
	LWD Pieces per Jam
	Reference Point Survey Post 1991

More detail on module types can be found in the Data Modules table. The following map shows the stream systems for which habitat measurements were taken as well as the upstream extent of those measurements. Queries can be performed on the database to determine which modules and which in-stream habitat metrics were gathered for any particular stream. Stream systems can be queried in a multitude of ways including stream name, watershed name, WA Department of Natural Resources stream ID number, and latitude and longitude ID number as defined by WDFW.

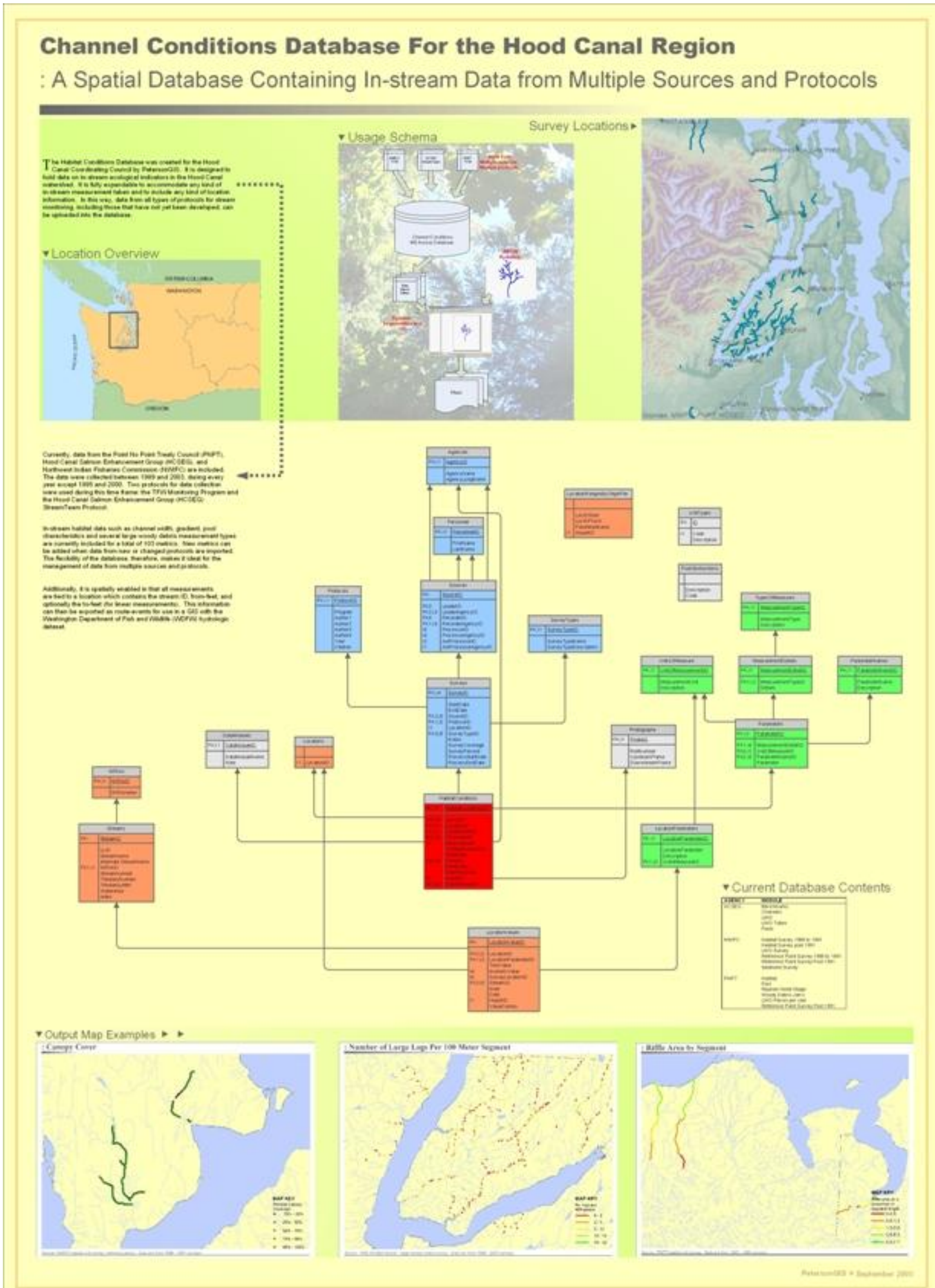


Database Diagram and Poster

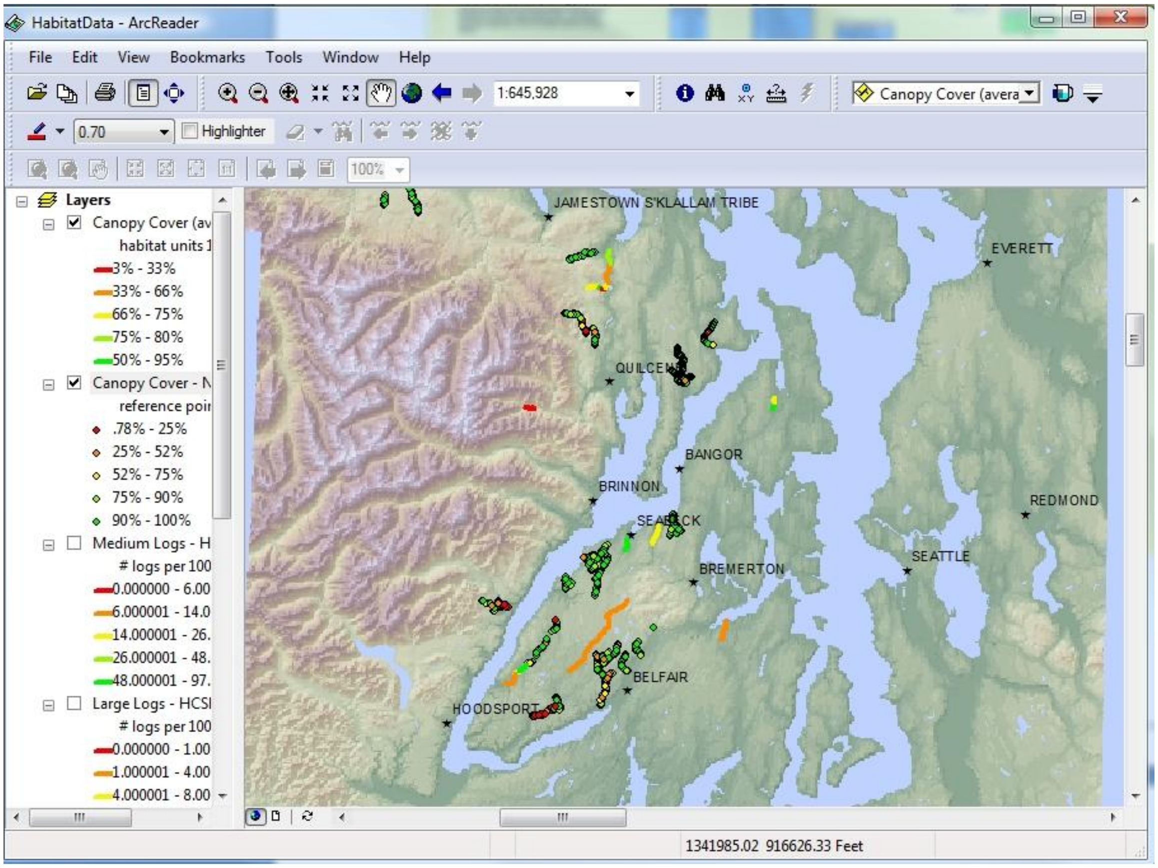
A database diagram and poster were created to showcase the organization of the tables in the database and example outputs. Snap-shots of them are shown on the following pages.



This is the habitat assessment database diagram. Each box represents a table and the fields in the table.


Channel Conditions Database For the Hood Canal Region
: A Spatial Database Containing In-stream Data from Multiple Sources and Protocols
Usage Schema
Survey Locations
Location Overview
Current Database Contents
Output Map Examples
: Canopy Cover
: Number of Large Logs Per 100 Meter Segment
: Riffle Area by Segment

An ArcReader map was also created in order to showcase some of the potential outputs from the database. ArcReader is a free GIS tool available for download that, when combined with the files that were prepared by PetersonGIS, will show background data as well as habitat conditions queries with the ability to zoom in and out and turn layers on and off. A screen shot of ArcReader with the Habitat Data project is shown below.



The following example shows how the database can be read directly from the tables:

HabitatConditions : Table

HabitatConditionsID	SurveyID	LocationID	DataModuleID	ParameterID	Measurement	TextMeasurement	StartDate	Phot	Field	DateRecorded	ImportID	DataStewardID
8552	296	133	2	1	92		7/22/1993	0		1/20/1994		1
8553	296	133	2	2	93		7/22/1993	0		1/20/1994		1
8554	296	133	2	3	86		7/22/1993	0		1/20/1994		1
8555	296	133	2	4	89		7/22/1993	0		1/20/1994		1
8556	296	133	2	5	93		7/22/1993	0		1/20/1994		1

Record: 929 of 187252

Surveys : Table

SurveyID	StartDate	EndDate	SourceID	ProtocolID	LocationID	SurveyTypeID	Notes	SurveyCoverage	SurveyPercent	ProcessStartDa	ProcessEr
294	7/19/1993	7/21/1993	5	1	632	1	SURVEY ENI	PRT			
295	7/22/1993	7/22/1993	5	1	633	1		WHL			
296	7/22/1993	7/22/1993	5	1	634	1		WHL			
297	9/23/1993	9/23/1993	6	1	635	1	SURVEY ENI	PRT			
298	10/1/1993	10/1/1993	7	1	636	1	SURVEY ENI	PRT			

Record: 11 of 312

LocationValues : Table

LocationValueID	LocationID	LocationParameterID	TextValue	NumericValue	SurveyLocationID	StreamID	Note	Date	ImportID
1672	132	3		3	0	4			
3433	132	2	RB	0	0	4			
1673	133	1		3047.90026247	0	4			
1674	133	3		4	0	4			
3434	133	2	RB	0	0	4			
1675	134	1		3343.17585302	0	4			

Record: 397 of 185965

DataModules : Table

DataModuleID	DataModuleName	N
1	Reference Points 1989 to 1991	
2	Reference Points post 1991	
3	Reference Point Survey post 1991	No habitat condition dat
4	Sediment/Gravel Surveys	No habitat condition dat
5	Sediment/Gravel Composition	
6	LWD Surveys	
7	LWD Level 1 Data	
8	LWD Level 2 Pieces Data	

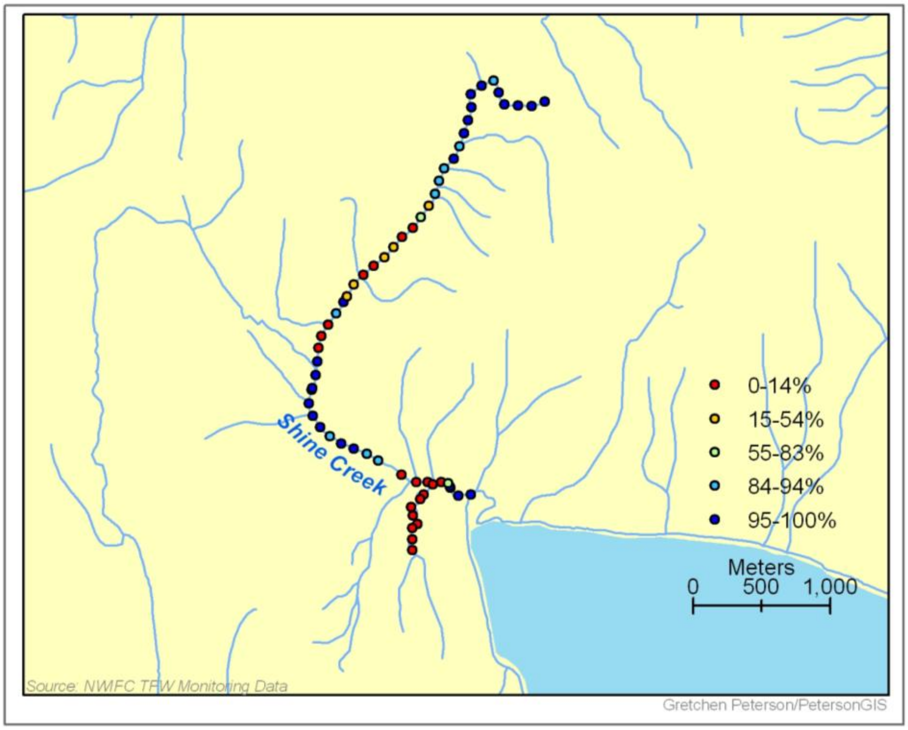
Record: 2 of 27

*Note that not all tables are shown

The data contained in HabitatConditionsID 8554 is as follows: Downstream Canopy (ParameterID 3) was measured at 86 (Measurement) percent (UnitOfMeasure 1) on 7/22/1993 (StartDate) for Thorndyke Tributary 17.174 (StreamID 4) at 3,047 feet (LocationParameterID 1) from the mouth, right-bank, reference point number 4. Additionally, information about the data module, in this case Reference Points post 1991, and the survey including agency and personnel (Phil Wampler, USFWS), and so-on are also linked to this measurement. To find all the canopy measurements for a particular stream, a query must be written, such as "Canopy Cover by Stream," found in the Queries section of the database.

It is useful to read the descriptions for the various database objects while exploring the database. While looking at a table in design view, for example, it is possible to read the descriptions of the fields contained within that table. Additionally, a brief description of the table, query, or report of interest can be viewed by clicking on View>Details while the main database window is active. Table relationships are viewed by clicking on the Relationships button while the main database window is active.

The database contains enough information for each measurement to place it on a map using GIS. To spatially enable the query "Canopy Cover by Stream," the output information LLID and From Feet (for point data: To Feet also for linear data) are needed. Streams in the database are linked to their respective LLIDs as defined in the WA Department of Fish and Wildlife (WDFW) hydrologic dataset. This dataset is required to make use of the LLID field. The LLID, from feet, [optionally: to feet], and measurement details, are exported to a dbf file and then imported into a GIS along with the relevant WDFW data. The dbf is treated as a route table in the host GIS and linked via the host GISs dynamic segmentation vehicle to the WDFW data. In this way, all the measurements in the database can be visualized in any manner made possible by the GIS and creates a rich environment for analysis. The following figure shows the result of a Canopy Cover by Stream query, once imported to the GIS:



Database documentation was created to be packaged with the database including: contentSummary, databaseDiagram, databaseSpecs, and userIntro.

The following is a metadata of sorts. It is really a stream of notes that were taken as the database was being created. A lot of useful but very specific information is in it and it is included here on the rare chance that someone needs to dig very deeply in order to understand the nuances of the data.

Notes on PNPT instream habitat database

Measurements were derived from a combination of the data and the report by Bernthal and Rot 2001. The report contains a map of the river and data tables - both were used to determine the measures. Data were assumed correct in this order: map, data table (first the river mileage, then the segment length), pnpt database.

If a stream description reports a specific entity (fish weir, road xing, etc.) at a segment break, that entity was located on the GIS and its measurement along the river taken and that measurement was then put into the database. When the maps showed segments breaking at river confluences, the corresponding segment break point locations were derived by locating these on the hydro layer and using the precise GIS measurements for these. This results in elongated/truncated final reference points for the segment that ends there but was thought to be the best way to keep things visually precise.

These reference points are obviously just rough estimates of their true location. The segment boundaries are more accurate. The reference points are probably plus or minus 1000 feet, with most being plus or minus 328 feet. The segments will be more accurate than that, especially where boundaries are defined by river confluences, road xings, or other locatable features.

BIG QUILCENE
Note, segment length of 1369 for segment 2 does not correspond with RM length of 1.3, nor does that correspond with the pnpt database segment length of 1300. The pnpt database segment length of 1300 was used because the subsequent measurements then lined up with the RMs.

LITTLE QUILCENE
The end of segment one and the beginning of segment 2 don't have the same bankfull width or depth recorded in the PNPT database. Therefore, it was assumed that, unlike most the other reference points for this and other streams, the end of the segment (1) was not at the same point along the stream as the beginning of the next segment (2). I just assumed that they were 100 meters apart in this case.

DEWATTO
1. Text and tables in Bernthal Rot refer to segment 2 beginning at RM 3. However, the map in the same report shows segment 2 beginning right where a confluence with a trib occurs (shown on the GIS hydro) and it was assumed that this was the starting place, with a corresponding starting distance of 17370.7 feet, or 3.3 miles. The report's map also clearly shows Segment 2 ending at another confluence with a trib, which is at 18765.419 according to the GIS hydro (or 3.6 miles). These measurements are significantly different from those recorded in the tables but will be used because they accurately depict the reference point locations, going by trib confluences as the most permanent distance marker. Similar discrepancies among the other segment measures, in all cases, the confluence distance shown on the GIS hydro were used, as these are the graphical components for the data. The map in the report does not show the river past the end of segment 7 so the rest of the segments relied solely on the survey lengths reported in the originating database. Overall, my distance modifications added about 1 river mile when compared to the distances reported in the table (mine ends at RM 8.6, the table says segment seg 10 ends at 7.7).

2. PNPT database for Dewatto Creek, segment 5 showed ref pt discrepancies depending on the particular module. This is because a decision was made to add reference points 0-4 into segment 4, as they were too deep to measure. However,

the data table for habitat shows ref pts 1-4 in segment 5 whereas the tblsegsum3 puts ref pt 5 data into ref pt 0.

To fix this, the correct measurements were put in tblhabitat but the segment number and reference point numbers were not changed. This means that I did not follow the note on the paper reports to "drop ref pt 0-4 from seg 5 and add them to seg 4" but instead kept them in seg 5. I could have dropped them from seg 5 but it would have meant renumbering all the habitat data ref pts which would cause problems if someone summed on a segment and compared that to previous reports on habitat data. The other data tables in this database start correctly at seg 5 so no need to change those. (Note added Aug 5, 2005.)

3. The PNPT paper reports show that the Dewatto has sediment data in paper form. However, it is not in electronic form in the database I was sent.

MCDONALD CREEK

1. Bernthal Rot 2001, page 22, states that the segment length for seg 1 is 6309, whereas the PNPT database "segment length" column shows a segment length of 7000. I must assume that the PNPT database is generalizing the segment lengths to simple 100 meter distances even though the field measurements weren't exactly 100 meters between each reference point. It is impossible to tell where the variations lie, however, so I will just have to truncate all the reference points to 90 meters apart. This way we will stay consistent with the segment length reported in table 9 page 22 as well as stay consistent with the map, which then shows segment 2 ending at the confluence with Pederson Creek, and in order to get that distance correct, we can't possibly make all the seg 1 reference points 100 meters apart. Similarly, segment 3 was changed to 80 meter apart reference points in order to get the rest of the segment boundaries to conform to what is shown on the map, in the table, and the GIS hydro layer.

2. The paper files for PNPT contain some temperature data for this creek that is not in electronic form.

3. It looks like the PNPT database is off by two reference points in tblsegsum3 for segment 3. This was determined by comparing the paper reports and their bankfull widths to those reported in the database. Ref pt data for the first 27 ref pts in seg 3 are missing from the paper files (starts at seg 3 ref pt 28). I'll adjust the database to match what I see on the paper reports as much as possible. We can't adjust these until we figure out where to put the two missing reference points. Will need to look at the carol disk? Carol's disk jut continues to confuse matters. The pts are off by two, that's for sure but where then should they get added in? There's probably a problem with seg 2 as well, but there are no paper reports for that segment to check. Note: Aug 22, 2005: We left the data as-is and we are going to assign a very small to and from distance to segment 3 reference point 35 as it is missing in the seg sum table. I want the segsum and habitat data to match up so this is the easiest way. It may not mesh with the paper reports but the issue is not solvable without making judgment calls that could be wrong. A

low quality confidence level is now assigned to the PNPT database because every time the data is examined closely little problems are discovered. This database is meant to collate the data rather than QA/QC it. A person who really wants to know absolutes will need to look at the paper data, but the database will give general ideas as far as average habitat characteristics. Of course that person who looks at the paper files won't get very far either but at least then they'd understand the limitations. Need to make notes as to where to get the original files, tied to the database somehow.

SALMON CREEK

1. The end of segment 2 and the beginning of segment 3 don't have the same bankfull width or depth recorded in the PNPT database. Therefore, it was assumed that, unlike most the other reference points for this and other streams, the end of the segment (2) was not at the same point along the stream as the beginning of the next segment (3). I just assumed that they were 100 meters apart in this case.

2. In the PNPT data, there were pictures taken for Salmon Creek along with comments as to where the pic was taken. These details are not in the database but are in the paper files.

3. In the PNPT database, there is a discrepancy in ref pt numbers for segment 2. The paper files show that seg 2, ref pt 5 did not have bf widths or depths recorded, but this is on a paper "check report for data entry" and not on the actual field form, which is not in the paper binder for the creek. The database shows refpt5 having the bankfull width and depths that the "check report for data entry" shows for refpt6. I'm going to revise the database to match the "check report for data entry" paper sheet, assuming that it is more accurate. There were a few transcription errors here. I fixed them as per the paper file.

SIEBERT CREEK

Segment 1 is shown on the map in Bernthal Rot 2001 as ending at the confluence with Emery Creek. This confluence is at river foot 18690 according to the GIS hydro layer. Therefore, the reference points in seg 1 were shortened to 90 meters apart in order to have them end at 18690. Similarly, reference points were made 95 meters apart in seg 2 in order for the end point to match with the next stream confluence as shown on the report map. The end of segment 2 and the beginning of seg 3 didn't have the same bankfull width and depths as is usually the case, so I went ahead and assumed they were 100 meters apart.

Note Aug 24, 2005: The tblPools data is incorrectly numbered for some of the units. For example, the tblPools data says that Siebert Seg 1, Ref 18, Unit 169 has length = 15 and width = 5. This comes right after Siebert Seg 1, Ref 16, Unit 198 on the tblPools data. If I then go look at the tblHabitat data, I see that Siebert Seg 1, Ref 17, Unit 169 has length = 15 and width = 5. Therefore, I conclude that the numbering is in error on the tblPools data for Siebert unit 198. I am going to renumber the segs and refs in accordance with the tblHabitat data.

Riparian Seral Stage table: the original seral stage table does not have precise location information. Only segment #, pool type, and pool length are found in other tables. No ref#s. It looks like the seral stage data were probably taken at reference points but the data aren't consistent with the other datasets. For example, some of the lengths and pool types in particular segments will match with reference point data but some will not so I can't use this info to get at ref #s. Furthermore, I can not put in the length and pool type data because this already exists from the other tables in more precise locations.

NOTES ON HCSEG DATABASE

Rendsland streams aren't spatially located yet. Matt Korb emailed 10/14/04 to say that the documentation on that stream is poor and he can't figure it out either.

Original data has a mistake for Big Bend, unit #1, it only has 4 sections and the stream distance continues on. These numbers, then, could be 100 meters off. Dalby is the same way and so is Big Bend trib1. **on second thought, about ½ or so of the streams only have 4 reported benchmarks in Unit 1 so I had to go through and find those manually and then correct my automated stream meters calculation for those (by subtracting 100).

5/11/05 note
I fixed the above: Matt Korb sent me an email with the right measurements for Outlet.

Dates 1/1/1992, 1/1/1993, 1/1/1994 in habitat conditions table just mean 1992, 1993, 1994 from the PNPT data they didn't have months and days but I needed a month/day for the date field format.

NOTES ON THE NWIFC DATA

see email 5/19/2004 with Richard about Snow measurements

The habitat conditions database was presented at the Instream Water Management conference in September 2004. The presentation was titled, "Channel Conditions Database: Stream Channel data storage and retrieval system." The slides for the presentation are condensed and shown on the following pages.

Channel Conditions Database

Stream channel data storage and retrieval system

Specs

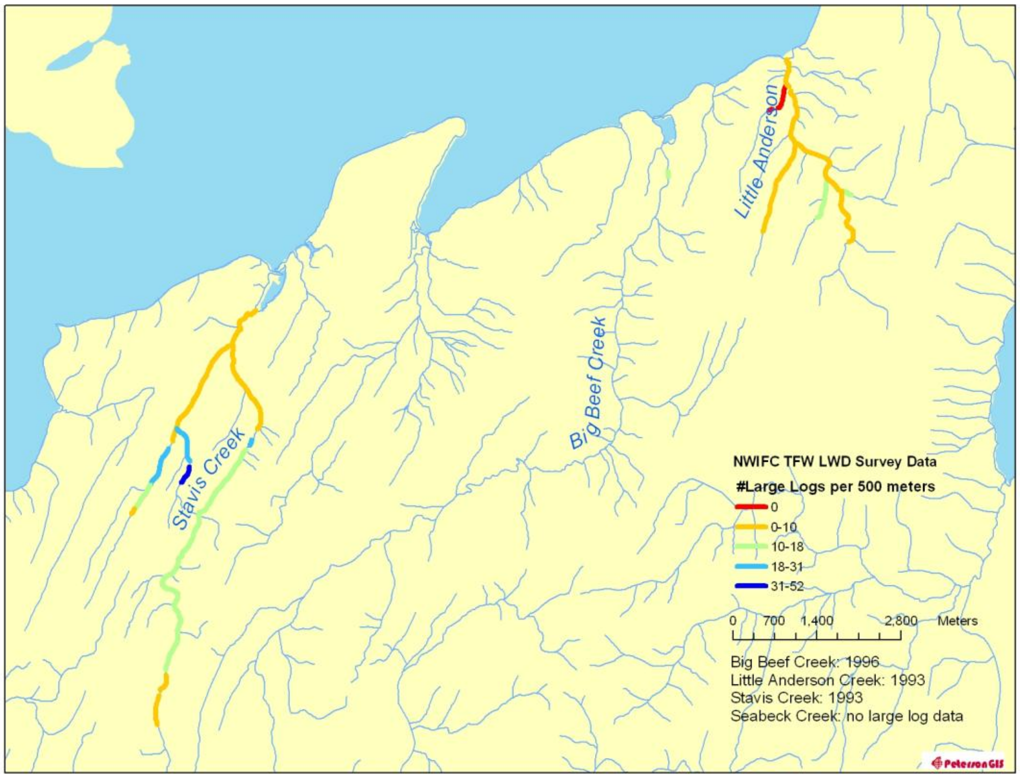
- Access database
  - Ease of use for import and export
  - Easy to distribute
- Relational table structure
  - Minimal redundancy
  - Facilitates data update/change
  - Extensibility

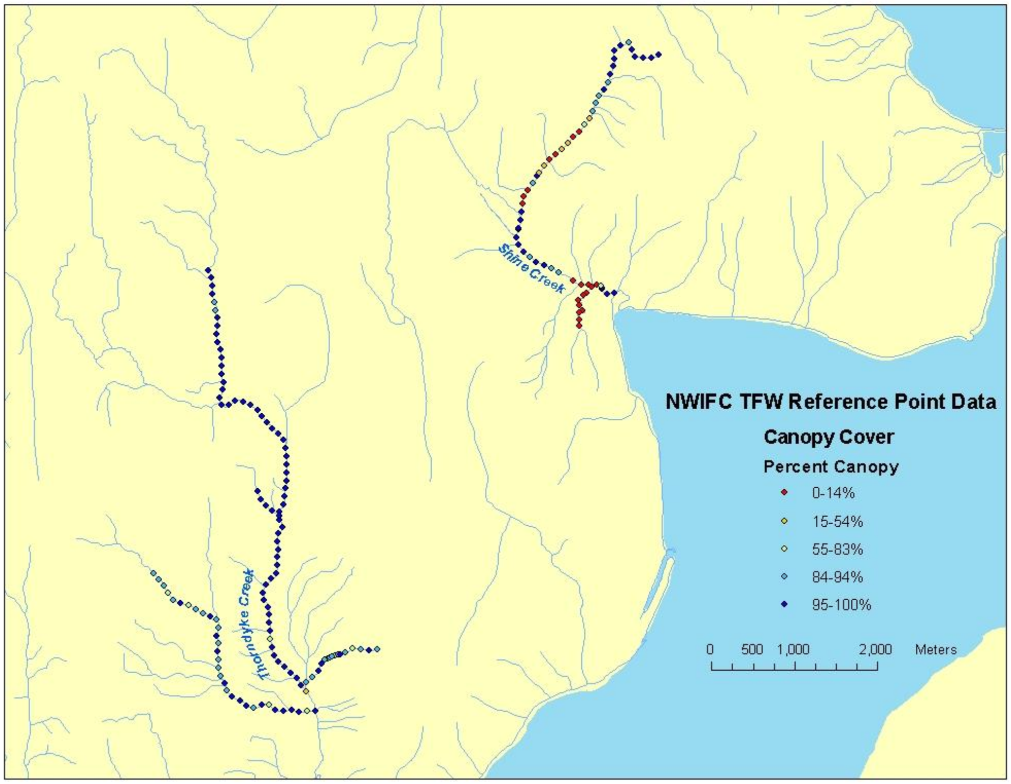
Benefits

- Can store any type of measured data, even new types as data collection evolves
- Reduced size from flat files
- Interface capabilities
- Query environment

GIS connection

- All data are location-based
  - Each stream has an LLID
  - Every measurement has a from and to location
- Export via query with LLID and from and to
- Import to GIS
- Link with WDFW hydrology using LLID and from and to measurements to visualize/analyze data


Little Anderson
Big Beef Creek
Stavis Creek
NWIFC TFW LWD Survey Data
#Large Logs per 500 meters
0
0-10
10-18
18-31
31-52
0 700 1,400 2,800 Meters
Big Beef Creek: 1996
Little Anderson Creek: 1993
Stavis Creek: 1993
Seabeck Creek: no large log data
PetersonGIS


NWIFC TFW Reference Point Data
Canopy Cover
Percent Canopy
0-14%
15-54%
55-83%
84-94%
95-100%
0 500 1,000 2,000 Meters
Shine Creek
Thorndyke Creek